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Introducing PBL in Engineering Education: Challenges Lecturers and Students Confront*

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Problem-based learning (PBL) is widely used across the professional education sector and is now emerging in engineering education as both a viable and effective teaching and learning strategy. PBL originated some 45 years ago in medical education at universities in McMaster (Canada), Maastricht (Netherlands) and Newcastle (Australia) and since then has gained popularity worldwide in many professional disciplinary fields. The PBL approach, as presented in literature, supports a shift from teacher-directed, or centred, learning to facilitation of students' learning, thus shifting the focus to students' learning. Facilitation, as practiced in PBL, involves a different style of teaching compared to traditionally accepted styles, and from the experience of both students and lecturers, brings with its adoption challenges. Importantly, a skilled PBL facilitator, who is secure in their role, can contribute significantly to the effectiveness of PBL groups' work and thus to students' learning. This paper reports on a qualitative study, and its findings, concerning the experiences of academic staff and students at one institution, the German Malaysian Institute (GMI), in Malaysia. During interviews and focus groups, lecturers and students identified the challenges that lecturers face in effectively facilitating PBL. Analyses revealed two major themes that inhibit success: lecturers' and students' adaptation to PBL. These findings provide interesting insights into what is required to adapt to this mode of delivery.

Keywords: problem based learning; engineering education; PBL challenges; PBL adaptation

1. Introduction

The dual factors of globalisation and industry's needs have highlighted the need for change in the engineering education landscape. Among the many challenges confronting educators today is the divergence between the goals of curricula and the demands of the workplace [1] relating to the long-standing argument of "theory versus practice". To meet these demands, educational institutions need to be responsible for delivering graduates with the necessary knowledge, skills and attitudinal competencies to meet the demands of globalisation. Graduates need to be equipped to be effective practitioners in the workplace, with an appropriate balance of technical knowledge supported by the appropriate soft skills required by their potential employers [2, 3].

PBL and its variants have been deemed appropriate for meeting the needs of both educators and industry in preparing engineers for the 21st century [4]. PBL was first introduced at McMaster Medical School in Canada, in 1969, followed by the development of PBL curricula at medical schools of the University of Limburg at Maastricht, in Netherlands, and the University of Newcastle in Australia [5, 6]. From these initial efforts in medical education, PBL spread widely, most notably in such disciplines as architecture, construction management, engineering, law, business and management, archaeology, information management and physics [7-8]. Specifically, PBL is being increasingly adopted as a learning and teaching strategy in engineering education worldwide, including in Malaysia, the context of this study.

While research suggests that PBL is an effective approach to promote learning, those delivering a curriculum change experience challenge as the roles of teachers change from a traditional lecturer to a facilitator [4, 8, 9]. However, the challenges and barriers of being an effective facilitator, in a PBL learning environment, have not as yet been fully addressed [10], including in engineering education. Furthermore, how lecturers manage these challenges in the engineering field remains largely under explored [4]. The study, reported in this here, was designed to examine the challenges lecturers face in implementing PBL in engineering education in Malaysia.

2. A rationale for change

PBL has a history of over 40 years in university education. It was originally implemented in medical

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schools in the late 1960s and has subsequently been adapted to other academic disciplines, including engineering education. One factor which has been found to be vital to the successful use of these methodologies is the effectiveness of the tutor/facilitator [11, 12]. PBL facilitation demands a radical shift from teacher as traditional content expert, imparting knowledge, to a co-constructer of knowledge in a student-centred learning environment [13, 14]. According to Barrows and Tamblyn, PBL is learning that results from the process of working towards understanding the resolution of a problem. The problem is encountered first in the learning process [12]. After the introduction of the problem, PBL teachers can no longer play the 'sage on stage' role of lecture-based learning environments. The PBL teacher becomes a tutor or facilitator.

The primary aims of engineering education are "to produce broad-based, flexible graduates who can think integratively, solve problems and be lifelong learners" [15, p. 234]. Evidence suggests that PBL has been at the core of significant developments in engineering education [16]. PBL in engineering education was firstly implemented at Aalborg University in Denmark in 1974 [17]. The traditional Aalborg model, founded on problem-based project work, is used in all study programmes within the Faculty of Humanities, the Faculty of Social Science, and the Faculty of Engineering and Science [17]. The Aalborg model has grown to encompass all engineering institutions in Denmark who have developed their teaching on the basis of problem-based learning and project work. Woods applied PBL in Chemical Engineering programs at McMaster University in the early 1980's [18]. In Belgium, a comparison between a traditional curriculum in engineering and a PBL curriculum being conducted since 2000, identified that PBL students improved their skills levels significantly compared to students from lecture-based curricula [6].

PBL has also been reportedly been successfully used in teaching a range of engineering courses including; civil engineering [19], microelectronic engineering [20], engineering design [8], electrical and electronic engineering [21], computer network design [22], statistical engineering [23] and construction engineering [24]. The application of PBL into such a broad range of engineering disciplines demonstrates its applicability to engineering education.

Despite wide-ranging support for the adoption of PBL in engineering [8, 25, 26], the transition to PBL brings challenges [4,8]. The main challenge is the dissonance between theory and its application, or practice [18]. This refers to the nature of engineering knowledge and practice compared to other disciplines, where PBL is widely adopted (e.g. medicine). The knowledge required in engineering is sequential, meaning that if students miss essential topics, they will fail to learn later concepts [26]. Further challenges include students' initial discomfort with their new roles in student-centred learning and inexperienced educators who are unfamiliar with their new roles as PBL facilitators [4, 9]. Some of the issues confronting facilitators include: group conflicts [8, 21], increasing workload [8, 9], PBL assessment expectations [27], being resource intensive [21, 27], time consuming [20, 27], enrolling a large number of engineering students [9]; the quality of PBL problem statements [9] and depth versus breadth of engineering curricula [21]. At present, there is little documented guidance to advise engineering educators how to manage all these challenges. The authors believe this remains an underexplored area.

3. Purpose of study

In PBL literature, a major concern is the role of facilitators [11]. Their attitude is seen as a critical factor which impacts on students' abilities to raise relevant questions and gives rise to critical learning issues [28]. Many PBL studies have focused on the characteristics of effective facilitators and how they influence student performance and satisfaction [29–31] Furthermore, these studies include, understanding the characteristics of an effective PBL facilitator of group processes [32, 33] adapting to group dynamics [34], encouraging the development of metacognitive skills [35], knowing when and how to intervene [36], scaffolding students' learning [39]; asking leading and open-ended questions [38]; encouraging and motivating learning [39], creating a positive atmosphere with positive personality traits [32,40]. Though there are several studies in this area, some issues still remain specific to the context of engineering education. Firstly, it is noted that the roles of the PBL facilitator is ambiguous and not easy to define since it might consist of many simultaneous roles and tasks [41]. Secondly, literature concerning PBL facilitation is inconsistent with respect to how facilitators can effectively facilitate PBL [29, 36, 40]. There is limited evidence of the challenges teachers face while facilitating PBL sessions. While research suggests that PBL is an effective approach to learning, there are challenges for teachers or tutors when changing instructional mode from a traditional role to that of a facilitator [4, 14]. There is thus a need to conduct further research relating to the challenges that teachers experience in employing a PBL approach. Finally, very few studies have been undertaken into PBL facilitation in engineering education, particularly with the objective to better understand the experi-

ence of teachers and students of effective PBL facilitation and its challenges in Malaysia. In response to the dearth of information regarding our understanding of how PBL implementation impacts engineering educators, the study reported here was established to examine the challenges lecturers face in implementing PBL in engineering education at the German-Malaysian Institute (GMI) in Malaysia.

4. Research design

A qualitative case study approach was adopted to meet the need to better understand the way that students and lecturers implement PBL. According to Stake [42], case studies are a strategy of inquiry in which a researcher explores in depth a program, an event, an activity, a process, or one or more individuals. The case(s) are bounded by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time [42]. The case study approach was for this study. GMI provided a context that allowed the researcher to identify, explore and understand the issues confronting students and staff alike. It provided a location where an institution-wide strategic initiative to introduce PBL was being implemented.

5. Data collection, sampling and ethical considerations

Semi-structured interviews were conducted using a loose structure of open ended questions that defined the area to be explored, from which the interviewer or interviewee could diverge to pursue an idea in more detail [43] This approach allows participants to express their views and experiences without any restriction [44]. Using this type of interview can encourage participants to view their experiences objectively. In addition, using interviews as instruments for data collection suggests that the views and understandings of a research context by a certain group of people relates explicitly to the research questions generated for a study [45].

Potential teacher and student interview participants were selected by purposive sampling. Purposeful sampling is a non-random method of sampling where researchers select 'information-rich' cases for in-depth study [44]. In other words, purposeful sampling occurs when a researcher selects a sample from which the most can be learned and when all subjects are too numerous to include. In this study, twenty lecturers from all academic positions across the departments at GMI were selected to participate. They represented different academic levels, genders and years of experience to establish various profiles of lecturer expertise and competence in PBL facilitation.

For the students, semi-structured interviews were conducted in a focus group setting. These were used to obtain detailed information concerning students' experiences, opinions and feelings about the research problem. They explored participants' knowledge and experiences and harnessed the synergistic effect of group interactions that would otherwise remain hidden [46]. The selection of student participants was based on purposive sampling. Six focus groups were conducted, where each focus group consisted of five students from the same semester. A total of thirty students were selected to participate in the focus groups. The groups were restricted to a maximum of five students to encourage their full participation and to ensure discussions were in depth. Each group consisted of students in the same year of study. In particular, there were two focus groups for each first year, second year and third year cohort respectively. The reason for this grouping is that students' experiences were expected to be different for each semester and it was deemed beneficial to obtain data from a homogeneous group. All the interviews, which were audio-recorded, lasted 60–90 minutes.

Specifically, the interview questions used to direct the study in exploring the issues identified in this paper were:

Interview with lecturers:

> *What do you see as the most significant challenges/ barriers in facilitating PBL effectively? Why?*

Focus group interview with students:

> *What challenges do you think your lecturers face in facilitating PBL sessions? Why?*

Approval for the study was obtained from the ethics committee of University of Newcastle (approval number H2014-0124). Ethical considerations of confidentiality, anonymity, and the ability of the participants to exercise their right to participate, withdraw or abstain from the study, were implemented throughout the entire research process.

6. Data analysis

In the first phase of data analysis, NVIVO 10.0 software was used to manage data and assist with transcription. All audio recordings of interviews with the 20 lecturers and 30 students were imported into NVIVO. The application was used to facilitate transcription by using the play, pause, skip back, skip forward buttons. The procedures for analysis included formatting the transcribed documents using headings. This was done to utilise the auto-coding technique in NVIVO. Lines of transcripts

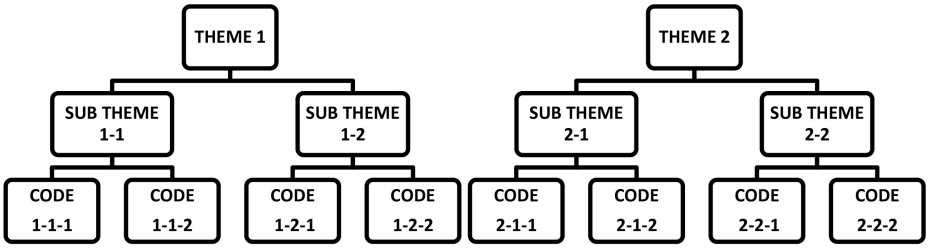

Fig. 1. The connection between Themes, sub-themes and Codes.

were put in rows and columns and numbered so that exact locations in the text could be specified, allowing the researcher to recode as needed. Each completed transcript was indexed using a pseudonym to replace the name of the lecturer and focus group participants. The pseudonyms made it possible for the original data to be retrieved and cross-referenced during writing-up and reporting.

The data were then analysed manually using a framework of thematic analysis, as recommended by Braun and Clarke's in their step-by-step guidelines [47]. These consist of familiarisation with data, generation of initial codes, searching for themes, reviewing themes, defining and naming themes, and producing a report. The transcripts were read repeatedly to search for emergent themes throughout the process of the study. Similar topics were clustered together as initial codings and matched with data extracts that demonstrated the code. These different codes were sorted into potential themes. The researcher then listed all potential themes, identified overlaps and combined these into new themes. The researcher identified whether a theme contained any sub-themes. Sub-themes provide a useful structure for a large theme of data and also for demonstrate the hierarchy of meaning within data. Fig. 1 illustrates the connection between the themes, sub-themes and codes applied in this study.

After continuous revision of the themes in relation to the research question, the researcher was able to identify the final themes and sub-themes. In summary, data was organized and refined; the most descriptive wording for each topic was found and then used as themes and sub-themes.

Table 1. Challenges that lecturers' face in delivering PBL courses in engineering

Themes	Subthemes
Lecturers' adaptation to PBL	• Transition to a new role • Lecturers' mind-set • Management of group dynamics
Students' adaptation to PBL	• Initial anxiety and struggle • Lack of knowledge, skills and attitude

7. Results and discussion

Analysis of the data about the challenges that lecturers face in facilitating PBL yielded a number of main themes, two of which are reported here: lecturers' adaptation to PBL and students' adaptation to PBL. Several subthemes were also identified as shown in Table 1.

7.1 Lecturers' adaptation to PBL

The facilitation of PBL demands a shift from teacher-centred to student-centred instruction. To effectively facilitate PBL, lecturers must adopt new roles that are very different from those of their past. In lecture-based instruction, the lecturer main role is as content expert imparting knowledge to students. In PBL, the lecturer design the problem, presents it to the students, and provides direction for student independent research. The lecturer functions as a facilitator. For many GMI lecturers, they face challenges in adapting with the new approach. From the responses, three subthemes of lecturers' adaptation to PBL were identified as shown in Table 1: Transition to a new role, lecturers' mind-set and management of group dynamics.

7.1.1 Transition to a new role

Fourteen of 20 lecturers (known at GMI as 'Technical Training Officers' (TTO)) interviewed described the challenges of transitioning to a new and unfamiliar role. Interestingly, nineteen of these TTOs explained that their own education and their teaching experiences to date were traditional and teacher-centric. Some were not prepared to make paradigm shifts to a teaching approach that was student-centred. Typical comments by those interviewed included:

> *TTOs may be resistant to change because PBL are different to their normal teaching. Since we are accustomed to traditional education, it is quite a challenge to depart from that system and adapt to PBL.* (TTO 3)

> *TTOs felt traditional lectures and practical work very well with technical education. They have practiced for such a long time and have successfully produced many good students. So why change?* (TTO 16)

> *Some TTOs do not change their thinking from the old*

paradigm of teaching (still teach not facilitate), some misunderstood the role by simply supervise . . . even from far . . . and do not guide or coach in between the process (if needed). (TTO 10)

However, some TTOs were positive about their experiences of transitioning to PBL.

For me PBL is not that difficult. All this while, I've been doing some sort of student-centred learning in my class. I let students do their own work. I don't spoon-feed with all information needed. I encourage students to work in groups. Once they got stuck, I will guide them. (TTO 15)

Some of the TTOs commented that they felt nervous about facilitating PBL modules, but they had become comfortable through the experience of implementing this approach.

It is not easy to change your role overnight. I feel anxious. It's a struggle for me not to be in control 100%, but to let students find the answers themselves. But after experiencing many PBL classes, I do enjoy the process and look forward to conduct PBL. (TTO 6)

Initially, I was uncomfortable with PBL, but with more experience I'm getting better. On the positive notes, many of my colleagues don't know much about PBL, but still try their best to implement it in class. (TTO 9)

From the students' perspectives, the challenge for TTOs is to be knowledgeable because in a PBL environment, students ask many questions.

When we research, we always come out with new information that needs clarification. In our class, students always ask many questions, sometimes beyond syllabus coverage, so TTO must be prepared and equipped with sufficient knowledge. (Student 3, Focus Group 1)

For example, when we present in the class, TTO should not embarrass themselves by saying "Oooo, I see! . . . now I know why!." For me, it seems like TTO don't know much about the problem under research. (Student 2, Focus Group 4)

Similarly, some students said it is a challenge for TTOs to provide sufficient guidance to problems.

In PBL, students need to find solutions on our own, but we still need confirmation from TTOs . . . some TTOs don't answer our question directly . . . maybe they don't know the answer... so they beat around the bush . . . ended up . . . we are not sure if our answers are correct. (Student 1, Focus Group 6)

Students also spoke about the challenges in providing quality facilitation and sharing of knowledge:

I don't agree with some TTOs who leave us in the library to work totally on our own. Even though in PBL students must work independently, TTOs should monitor our progress, and be there in case we have questions to ask. (Student 4, Focus Group 2)

We appreciate if TTOs can share their working experiences, examples of real life applications and other relevant knowledge. Some TTOs did that. (Student 2, Focus Group 4)

In general, the comments are consistent with reports in literature about lecturers' attitudes as they shift from teacher-directed learning to facilitation of student learning. It is difficult to convince staff to shift paradigms and this is common in the early stage of implementation [9, 16]. Normally, lecturers feel confident and satisfied with existing teaching practices and few staff members feel the need for change. Lecturers' comments suggest that as they become familiar with PBL, they are more comfortable and confident in teaching using this mode of instruction. The transition to the new role of facilitator also requires educators to equip themselves with both knowledge and facilitation skills. Proactively, many GMI lecturers had implemented PBL, although some did not have the opportunity to attend any formal PBL training.

7.1.2 Lecturers' mind-set

The perspective of eight of the TTOs interviewed was that a TTO must possess a positive mind-set to implement and facilitate PBL. They must be willing to accept changes. As one TTO commented:

PBL is all about TTOs' willingness! When there's a will, there's a way. It can be difficult at first, but TTOs must be positive to accept it. When you think positive, everything will fall in places.. it's all in your heart whether you want to embrace it or not!. (TTO 17)

From another perspective, some TTOs had negative feelings about this approach because PBL increased lecturers' workload; thus it is a burden.

With PBL, we need to prepare so many things . . . crafting problem statements, scaffolding student learning, change the assessment structure, prepare physical materials like mah-jong paper, manila cards, marker pens . . . etc . . . so much work to do. (TTO 5)

The lack of confidence in PBL itself might also cause TTOs to have negative feelings about this approach.

TTOs need to have confidence in PBL and look at its benefits. From there they can convince the students to participate. PBL would not work unless TTO is convinced about using PBL, rather than they implement it because it was instructed by the management. (TTO 18)

Some TTOs received incorrect information about PBL, demonstrating the importance of a well-structured implementation plan. For instance, there was resistance from some experienced TTOs because they considered that PBL was not suitable for engineering courses:

There are some difficulties in implementing PBL in my courses. The time is not enough to cover syllabus because my course involves almost 100% practical (hands-on). (TTO 13)

Some complained . . . PBL may work for you, but it wouldn't work well for me . . . because my subjects involved real machineries . . . It would be dangerous to let students operate the machines on their own. (TTO 3)

Similarly, a TTO commented that he still preferred traditional methods over PBL. As with most innovations in teaching, there are those that are unconvinced of the benefits or unwilling to change, as evidenced in the following statement:

> *I conducted PBL a few times. It is OK. However, in my opinion, I still prefer lecture. I am completely sure of what to deliver and the expected learning outcomes.* (TTO 9)

In addition, some TTOs did not take the initiative to learn about PBL. They assumed that their implementation of the methodology was appropriate.

> *Some of my colleagues replace PBL session by giving tasks to student. For example, go study this chapter and present it in class. So where (does) that involve a problem statement? This is a totally wrong concept.* (TTO 2)

A lecturers' attitude is an important contributor to the successful implementation of PBL as explained by a TTO.

> *OK, some TTOs complained about lack of PBL training, but even during training these TTOs don't take it seriously. There are cases where some TTOs attended PBL trainings for many times and yet still do not take initiative to conduct PBL in their class. I know it because I was the one who gave them trainings few times.*
>
> *So the issue here is TTOs' willingness to implement PBL.* (TTO 19)

Similarly, students commented that TTOs' attitudes towards PBL are a challenge to effective facilitation. If TTO commit to PBL wholeheartedly, students will gain the benefits of PBL and vice versa.

> *I always look forward to attend Network Ethics PBL class. She is the best TTO!. She will never provide us with answers easily, but will make us work hard for it. She is positive that we can solve the problems.* (Students 2, Focus Group 3)
>
> *My Digital Electronic TTO will be in the class all the time checking our work. She explains the tasks clearly and encourages us to be creative when it comes to presenting findings.* (Student 4, Focus Group 4)
> *I am not sure if TTOs take PBL seriously. Many TTOs just assign us problems and leave us to work independently.* (Student 5, Focus Group 1)

All the comments presented above clearly show that a positive attitude toward change is crucial in ensuring the effective implementation of PBL. This is consistent with Glew's findings which attribute reasons of PBL failure to a range of factors, including both insufficient guidance from the facilitators and also to the facilitators who do not practice facilitation according to the guidelines provided by curriculum designers [48]. Facilitators need to become familiar with PBL processes, gain confidence in PBL and be committed to its implementation. Only then can students experience fully the benefits of PBL

7.1.3 Managing group dynamics

Eight of 20 TTOs identified group issues as challenges in facilitating PBL. In the GMI model of PBL, students are encouraged to form their own groups of approximately four to five students. Students have different personalities, attitudes and attributes, hence inequalities in groups are inevitable. For example, there are inequalities in terms of students' participation levels, abilities, capacities and different levels of competencies. Therefore, conflicts will arise. One TTO illustrated the situation.

> *Some students are 'free loading'. They did not focus in class, and take advantage of their group members in completing PBL tasks. It happened either because they are weak students or maybe because of their negative attitudes. Sadly, these students sometimes get away with it because their group's performance is good. That is why in PBL assessments, we need to have individual marks too, not just group marks.* (TTO 4)

Alternatively, it may happen that one student dominates a discussion and other group members just follow because they don't want to create a scene or challenge the dominant student.

> *Some students dominate the discussion inappropriately . . . the more quiet members would simply not challenge them. These dominant students sometimes speak on irrelevant issues and take group's time. So, TTO needs to have skill on how to manage group dynamics. We need to encourage the quiet students to talk. Overall though, most groups can work well together.* (TTO 2)

Lecturers identified another form of dominant student, one who motivates their group members positively. Their enthusiasm helps others to engage with the learning process by making productive contributions to group discussions.

> *Sometimes if there are some weaker students in the group, the good students can influence them in positive way. Help them to solve the tasks collaboratively. Usually, I can see during class presentation how the weak students improve.* (TTO 1)

In addition, student absence is another challenge confronting lecturers. Absent members are likely to disrupt

group activities since, in PBL, students divide work and everyone must complete their parts. One lecturer described her opinion about this:

> *Those absent students affect group work. To be fair, I always set ground rules. I will make sure the absent students complete tasks to the minimum standard and students must comply regardless of their wishes. No marks will be given if students did not complete their parts.* (TTO 17)

Students shared similar views about the challenges lecturer face in managing group dynamics. Students like group work but at the same time there are

conflicts with group members as described in the following quotes:

> *Working in group is great. We can share opinions. Work can be completed faster. The disadvantage is that you are relying on other people to get work done on time. If they don't deliver, the whole group is in trouble. For me, it is only fair that TTOs must know who really did work and who doesn't.* (Student 3, Focus Group 3)
>
> *Group work is OK but some group member is like a boss, they give you most of the work . . . some member depends on other people to do work for them. Some students are weak and some are good. We need positive group dynamics where everyone contributes equally.* (Student 2, Focus Group 2)

Lecturers noted that group dynamics played a vital role in students' experiences of PBL. Lecturers reinforced the need for receiving training in topics like dealing with difficult situations and how to engage quieter learners in group discussions. This view is supported by Hung who writes that the group dynamics issue is an extremely difficult management problem and requires sophisticated tutoring and group management skills, which are often not possessed by first-time instructors [49]. This concurs with Salimah and Zaitun who found that lecturers feel they are inexperienced at facilitating group work and seek helpful tips to tackle unexpected situation [9]. In fact, tutors who are perceived as being skilled in group dynamics are evaluated more highly than tutors who are not perceived as being so skilled [40].

7.2 Students adaptation in PBL

Twelve of the 20 TTOs interviewed commented that students' adaptation and perception in the PBL class is critical and presents facilitation challenges. From the responses, two subthemes of students' adaptation level to PBL were identified as shown in Table 1: (1) students' initial anxiety and struggle in adopting the new approach, and (2) a lack of knowledge, appropriate attitudes and skills to engage with PBL.

7.2.1 Students' initial anxiety and struggle

Twelve of the 20 TTOs interviewed reported difficulty transitioning students into more active roles associated with PBL, as follows:

> *To have independent students in class is a challenge because they are more familiarised with teacher centred approach and mostly spoon-fed with information. They struggle to complete tasks on their own. They always come to TTO for answers.* (TTO 2)
>
> *Students are so comfortable with traditional method all their life, so the initial PBL implementation is difficult. Students cannot identify the learning issue. That is why they have problems in presenting and defending their findings, even though the real solution is very straight forward.* (TTO 3)

Similarly, another TTO thought that PBL could lead to teaching experiences which disheartened lecturers if students did not engage fully with the PBL process. This was especially the case for TTO who were trying to implement PBL as a new teaching method.

> *As a new TTO, I am very excited to try PBL. However, I noticed that with PBL, students don't really put effort in completing the tasks. They just do it for the sake of submitting the assignments without really understand it. When we ask them during class presentation, they cannot justify their answer.* (TTO 9)

In addition, there are students who did not cope with learning in a PBL environment:

> *I received complaints that students found PBL are too stressful. Most of the courses follow PBL syllabus, therefore students have so many tasks to complete at one time. They become too overwhelmed with this.* (TTO 12)

Similarly, the majority of the students interviewed commented that TTOs face challenges to facilitate and orientate them to PBL, due to students' unfamiliarity with the new approach. Interviews with students provided an insight into why the initial transition was a struggle and provided some suggestions.

> *PBL is very different from the conventional method I went through at school. At first I find it difficult. I felt lost. TTOs didn't help much. They just ask us to research more. To make it worse the group work is slow and inefficient. TTOs should orientate students to PBL thoroughly, make everyone understand what PBL is, and guide what to do to finish the task.* (Student 5, Focus Group 5)
>
> *Initially PBL is hard. But after going through the process, I like PBL. I think TTOs must first identify those students who are weak and require extra support. TTOs must know how to engage students in discussions, and let everyone participates.* (Student 4, Focus Group 3)

These comments show students experience initial discomfort with PBL and that teachers need to have the capacities to help them to transition smoothly from conventional methods to PBL. This is consistent with the findings that highlighted students struggle to adapt to PBL when they first encounter it [4, 16]. Students may at first react to the PBL practice with shock, denial, anger and resistance. Pepper stated that in the "early stages of PBL implementation, it is vital that students receive guidance about how and why they are expected to work in new ways" [50, p.704]. Students need to reassess their roles and modify their past study habits. Therefore, lecturers need to work to build confidence and guide students in their discussions before they were able to take responsibility for their own progress particularly with groups who have no experience of PBL.

7.2.2 Lack of knowledge, skills and attitude to cope with PBL process

Five TTOs suggested that PBL was not always appropriate for younger students, believing that PBL should not be used until students had a good grasp of the course content and had developed sufficient foundational knowledge. Some of these responses include:

> *From my experience, PBL is not suitable for first year students. Most of them never experienced PBL at school. Students cannot solve the problem given. They keep on coming to us for answers. So, in my opinion PBL should not be used until the students had enough prior knowledge. I prefer to use it in Semester 3 or 4 as then they would be ready for it.* (TTO 14)
>
> *My main concern is that first year students do not have skills to tackle engineering problems solving. They are not mature enough to handle ill-structured problems; therefore we need to craft a well-structured problem.* (TTO 4)
>
> *Engineering involves lots of math and science. Students are used to memorise lots of formulas and focus on solving equations. So to learn technical with PBL is not easy. Students need time to learn, especially new students coming fresh from secondary school.* (TTO 1)

Some students lacked confidence and were afraid to try new approaches to learning. They were concerned about giving incorrect answers. Some were simply not interested. Clearly, students need more time for adjustment to PBL.

> *Students are afraid of making mistakes. If we say like this they will ask why in the book says differently? They just want answers that can be used in the exam. Even after doing so many PBL, some students still think TTOs answer is the best.* (TTO 19)
>
> *Sometimes, I feel so frustrated when listening to group presentations. Most of the students just reading off stuff they don't understand or mention words that they don't even know what it means . . . They simply copied and pasted information from the internet.* (TTO 4)
>
> *It's not about PBL. It's all about students' attitude. Some are just not ready for college/university life.* (TTO 13)

Students were also of the same opinion, showing first year students' lacking knowledge, appropriate attitudes and skill in coping with PBL. These cause barriers for lecturers to facilitate PBL effectively.

> *At school, we are used to be guided fully by teachers. Majority don't have the skills to find information on our own or how to analyse problems. So, TTOs must equip students with skills such as information searching.* (Student 3, Focus Group 2)
>
> *Initially, we don't have confidence, we don't know what to do with the problem given.. how to complete the tasks. We are not confident to explore the problem ourselves. But I am sure with experience, and guidance from TTOs, we will improve.* (Student 4, Focus Group 1)
>
> *I don't understand what's so special about PBL. Maybe because we are not well informed about it. For me PBL is just like any other assignments. I do it just to get marks.* (Student 2, Focus Group 1)

The issues identified here align with those presented in literature where researchers observe that, if students lack the required background technical knowledge and the generic skills needed to undertake self-study, the objectives of PBL will not be fully achieved [21, 26]. Besides, there is evidence that students would like to learn in ways they are comfortable with, whilst taking less responsibility for their own learning [9]. Despite this, PBL can still be implemented early in engineering programmes. However, a structured approach is required with clearly defined problems and gradual moves toward open-ended problems [25]. This concurs with a study that found the level of technical knowledge of first-year students is insufficient to allow activities to be more than unstructured and unquantified exercises [27]. In addition, a study suggests that in the early stages of an engineering curriculum, PBL is a possible strategy to be used to demonstrate the application context [26]. Here teachers need to guide discussions because students are still unfamiliar with the method. Indeed, students respond positively towards PBL if they are fully informed and supported in the new learning process

8. Conclusion

This study has identified two major themes associated with the challenges lecturers face in implementing PBL in engineering. PBL requires all parties to reconsider the perceptions of their roles in traditional teaching environments. Academic staff need to adapt to the role of facilitators rather than lecturers while students have to be comfortable in taking an active role. While transitioning to these new roles, some lecturers are willing to embrace change, while others see it as a constraint. This highlights how lecturers need to be supported, trained and mentored as they undergo the paradigm shift from a traditional mode of instruction to a PBL mode. Therefore, staff development programs should include teaching staff the philosophy of PBL. Lecturers need to be both well-informed about the distinctive pedagogical characteristics of PBL and be trained in various aspects of PBL course development and PBL process facilitation skills. It is interesting to note that most of the lecturers involved in this study did implement PBL even though some received little training. This shows their commitment and willingness to embrace PBL.

Similarly, it is a challenge for lecturers to facilitate PBL if students experienced difficulty in adapting to PBL. To make the transition smooth for students, it is recommended that a thorough PBL orientation is provided to help students clarify what PBL is, the

roles of facilitators and students in a PBL environment, and to experience first-hand PBL processes. Such PBL orientation sessions, should inform the mind-set and attitudes of students to PBL. Most importantly, lecturers need to scaffold students learning and provide them with intensive support and guidance to build their confidence as independent learners. Reflections from the lecturers and students also established that PBL takes time to be fully adopted. It is expected that both lecturers and learners who experience PBL for the first time will find it challenging because they need to adapt to a new way of learning. Solutions to these problems were identified as crucial by both lecturers and students. Finally, this study contributes to the body of knowledge about PBL in engineering education research, especially the development of PBL in engineering education in Malaysia, which is sparse.

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