

## Introduction

Today's engineering professions are continuously experiencing major changes. The continually evolving workforce in engineering practice demands far broader skills than simply the mastery of scientific and technological disciplines. Various engineering education reports from throughout the world stress on the need for graduates who are equipped with both technical knowledge and professional skills that can help them function well at the work place (Duderstadt, 2007; Spinks, Silburn, & Birchall, 2006; Zaharim et al., 2010).

In response, many engineering faculties worldwide have engaged in strategic curriculum reform, and PBL is often seen as an effective strategy to achieve these desired outcomes (Hunter, Matusovich, & Paretti, 2012; MOHE, 2006). Literature reporting PBL implementation in engineering education (Graaff & Kolmos, 2007) has demonstrated that PBL is widely regarded as a successful approach.

PBL is an instructional and curricular learner-centred approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem (Savery, 2006). This learning strategy enables engineering students to develop competences such as problem solving, critical thinking, communication, time management, team working and leadership.

## Context

In recent years, PBL has gained popularity in Malaysia. However, only certain areas of studies are using this approach seriously, most notably in the medicine and engineering disciplines. To illustrate this, PBL was first introduced in Malaysia in medical education at The Universiti Sains Malaysia (USM) in 1979 (Zabidi & Fuad, 2002). In engineering education, as summarised by Wan Muhd Zin, Williams, & Sher (2013), the University Teknologi Malaysia (UTM) was the first to implement PBL in 2002, in the Department of Chemical Engineering. Subsequently, PBL has been used in engineering syllabi in the University of Malaya in the 2003/2004 session, in the Faculties of Electronics & Electrical Engineering at Universiti Tun Hussein Onn Malaysia (UTHM) in 2005, and in electrical engineering subjects at Polytechnic Port Dickson in 2009. Most of the PBL initiatives mentioned have been within courses (subjects) and to a lesser degree programs as a whole, rather than as full institutional adoption. In 2010, an established technical institution in Malaysia, the German-Malaysian Institute (GMI), which is the context of this study, introduced an innovative curriculum approach entitled 'Problem, Project, Production-Based Learning' (Pro3BL). This educational teaching and learning framework is based on a PBL model which is incorporated into the entire three-year curriculum of diploma programmes (Wan Muhd Zin et al., 2013).

The introduction of PBL as an innovative strategy is often challenging to both teaching staff and students alike, particularly when newly implemented. Several challenges noted in the research literature include student and teachers transitioning from lecture-based to self-directed learning (Strobel & Van Barneveld, 2009; Yusof et al., 2004), faculty training and support, concerns over content coverage (Hunter et al., 2012; Kolmos et al., 2007), designing effective problem statements, additional time to prepare course materials (Hasna, 2008) formulation of an authentic student assessment procedures and a perceived loss of instructor control due to the changed role of instructors (Kolmos et al., 2007; van Barneveld, Strobel, & Light, 2012).

These challenges and barriers faced by PBL facilitators have not been fully addressed (Savin-Baden, 2003) especially in the context of engineering education. Additional research is needed on the barriers, drivers, and challenges of PBL (Strobel & van Barneveld, 2009). The authors believe this, still remains an under-explored area.

## Purpose of Study

Although Malaysia is among the first Asian countries to introduce PBL, there are few publications that report on the impact of PBL implementation in this region (Servant & Dewar, 2015). In addition, the practice of PBL in engineering education here is still far from widespread. This project is part wider research, concerned with improving PBL implementation. The study reported here was designed to examine the challenges lecturers face in implementing PBL in engineering education. At GMI, lecturers are known by the title of “Technical Training Officers (TTOs)”. Therefore, for the remainder of this paper, a lecturer at GMI is referred to as TTO. In this study, semi-structured interviews were conducted to better understand the issues confronted by staff. It is argued that the use of semi-structured interviews is the most appropriate in this case as the interviewees were given a fair degree of freedom as to what to talk about, how much to say and how to express it (Drever, 1995). Specifically the interview questions used to direct the study in exploring the issues identified in this paper are: *“What do you see as the most significant challenges/barriers in facilitating PBL effectively? Why?”*

## Data Collection, Sampling and Ethical Consideration

This study used a purposeful sampling plan, where the respondents had to have both sufficient background and experience in PBL to provide rich and deep descriptions of the phenomena being studied (Patton, 2005). Twenty TTOs with teaching experiences ranging from two years to 20 years agreed to take part in individual interviews. All the interviews, which were audio-recorded, lasted 60-90 minutes. 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.

## Data Analysis

The analysis of data was undertaken using a framework of thematic analysis, as recommended by Braun & Clarke's (2006) in their step-by-step guidelines. These guidelines consist of familiarisation with data, generation of initial codes, immersion in the data, reviewing themes, defining and naming themes, and producing reports (Braun & Clarke 2006). The interviews and focus groups were transcribed and the analysis of the text was performed using the software package NVivo 10.0.

## Results and Discussion

Analysis of the data identified a number of themes, two of which provide the focus for this paper; training of PBL facilitators, and support from management and colleagues, as shown in Table 1.

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

Themes	Subthemes
Training of PBL facilitators	<ul style="list-style-type: none"> <li>• Curriculum design and development</li> <li>• PBL facilitation skill</li> </ul>
Support from management and colleagues	<p><b>From management:</b></p> <ul style="list-style-type: none"> <li>• Creation of PBL awareness</li> <li>• Continuous monitoring</li> <li>• Learning resources</li> <li>• Reward system</li> </ul> <p><b>From colleagues:</b></p> <ul style="list-style-type: none"> <li>• PBL support group for TTOs</li> </ul>

### Training of PBL facilitators

More than half the TTOs participating in this study described the challenges of insufficient PBL training. Those most frequently declared include trainings about curriculum design and development, such as how to craft effective problem statements, to devise assessment criteria and to manage time to ensure a syllabus is covered. Typical comments by those interviewed included:

*A major challenge TTOs' face is lack of problem crafting skill. Majority TTOs do not have this skill. I for one don't really know how to craft good problem. (TTO 14)*

*The thing is... there is no standardization for assessment... TTOs who teach the same subject don't practice standard assessment. For example, some assess on both group work and individual. Some don't. so it's not fair for students. (TTO 2)*

*PBL takes a lot of students' time, ...they need to do a lot of research ...solve problem... and prepare for presentations. Lots of activities involved, so TTOs need to be trained how to use time effectively...otherwise there's no use of doing PBL. (TTO 13)*

A similar outcome was reported by Clancy (2005) who found that many PBL educators expressed concerns about time taken to prepare and present using PBL, designing appropriate problems, the assessment process, and support. These components are essential for a successful PBL curriculum. Farmer (2004) suggests that faculty should undertake PBL training prior to problem writing and assessment workshops because once staff have a solid grasp of the PBL process, they are in a better position to design problems and assessment structures.

The TTOs interviewed, were also concerned about having specific PBL facilitation skills, including, how to facilitate PBL sessions effectively, to allow students to develop problem solutions on their own and to avoid giving direct answers, how to manage group dynamics and to give feedback and how to encourage reflection.

*It's very tempting to give the answer or tell students how to get the answer since I am so used to traditional teaching. (TTO 6)*

*In PBL, students work in groups. But some students are 'free loading'. They did not focus in class... and take advantage of their group members. (TTO 4)*

*I conduct a feedback and reflection sessions at the end of PBL class presentation. But I know most TTOs end with feedback session, missing the reflection stage. (TTO 12)*

These observations are in accord with those of Irby (1996), who asserts that educators need to learn specific skills to facilitate learning in PBL classes such as asking questions, encouraging equal participation, challenging evidence, setting learning objectives, giving feedback, evaluating learner performance, and examining the process. Lecturers need to improve their facilitation skills so that they can more effectively guide students.

The majority of TTOs also responded that they were unsure if they had the underpinning knowledge and skills needed to implement PBL. Particularly, early-career TTOs suggested that their lack of PBL experience and delivery training had a direct influence on their confidence:

*New teaching staff like me, needs to receive training the most. Many of us are unsure about the right PBL method. Students complained they get confused... this TTO conduct PBL this way ---- that TTO use different way ----somehow I lose confidence to implement PBL because I don't know much about PBL process or how to facilitate PBL. (TTO 9)*

New faculty members joining the institution expressed naivety about PBL processes but were expected to facilitate PBL sessions. Furthermore, different TTO backgrounds and different levels of training have resulted in a broad range of TTOs' preparedness to deliver using the PBL approaches. A senior and experienced TTO described explicitly the PBL trainings systems at GMI:

*When PBL was first introduced, management has taken a lot of initiative such as sending staff to PBL trainings at overseas, attend PBL seminars and conferences at overseas, and conduct many PBL workshops. But, from what I can see, after 4 years of PBL (implementations), the trainings are getting less and less. Ideally, management should continuously prepare TTOs for PBL. (TTO 3)*

Some TTOs commented that staffs were given one-off training, which was perceived by participants as insufficient. Some TTOs who had attended training do share their learning more formally with other staff, while some do not, as described in the following comments:

*I attend PBL training once and that's about it. The department will usually call other TTOs for the next workshop. It is good if the trainings are continuous. But focus on different aspects of PBL. Such as, workshop on PBL assessment. (TTO 2)*

TTOs feel that one workshop is insufficient to gain an understanding of PBL approaches necessary for confidence and effectiveness. They feel an intensive workshop is required to increase confidence in carrying out PBL activities in their courses. TTOs specifically indicate a need to formulate an appropriate and standard assessment method to evaluate students' performance. This reiterates the views of Hendry (2009) who argues for PBL training to be more than a one-time staff development activity. Facilitators should have follow-up sessions with their trainer, be observed by a trainer, and seek feedback from their students (through surveys and verbal discussions) to grow and develop as effective facilitators (Leary, Walker, Shelton, & Fitt, 2013). Hendry also suggests that training should be conducted through continuous training sessions rather than having a major training workshop before the academics start implementing any new educational models.

TTOs also complained that the PBL training sessions given were largely generic and did not address specific individual issues associated with engineering.

*I think PBL trainings are better conducted according to departments. What we practice is, all TTOs are put into the workshop together... to all learn same thing. (TTO 9)*

*I would like to suggest GMI PBL trainers to come from engineering discipline, not from English or Math because we want to learn, especially on how to craft problem statements. The facilitators cannot help much when we ask them examples of PBL engineering problems. (TTO 1)*

TTOs also felt that PBL trainings could be more realistic. Authentic exercises and resources would, they felt, enable them to model the practices conducted elsewhere.

*To be honest, I'm not sure that the facilitation that I gave to the student is correct or not. There is no clear picture how facilitation in PBL should be conducted. I really wish that we can visit any PBL institution or have a video on actual PBL session or have someone come in and demonstrate PBL. (TTO 20)*

This is consistent with Azer (2011) approach where he suggests that visits to experienced staff at schools where PBL had been implemented would allow the faculty to construct a good PBL program that matches international standards, and avoids mistakes that could damage the program or affect students' learning.

### Lack of support from management

More than half of the participants reported that the lack of support both from management and colleagues contributed to PBL implementation being a challenge. One senior TTO expressed concern that the departments were lacking in creating awareness about PBL. As he recalled:

*Management should really prepare GMI before we start to use PBL ...such as create awareness about PBL to all staff and students. This can be done through pamphlets, posters, workshops so that everyone knows PBL is a big thing. This must be done continuously, not just do it at the initial phase of PBL implementation. (TTO 3)*

A similar viewpoint was shared by another senior TTO who commented:

*PBL is a new approach especially in engineering. It is important for the department to explain clearly what PBL is, so that staff and students are not left in the dark. I am sure if they are aware of the details and benefits of PBL, they will be ready to accept PBL. (TTO 20)*

To support the introduction of PBL, Azer (2011) suggests that management must ensure staff and students are clear about these changes and the reasons for the change. It is important to orient them to the PBL environment by explaining the rationale, educational theory and evidence for PBL. Induction into PBL processes supports and assists staff and students to adapt to the processes.

Other TTOs mentioned the lack of monitoring and evaluation by management. For them, the poor commitment and support staff received makes some TTOs take PBL for granted.

*PBL needs commitment from our management ...but right now, there is very little monitoring done ...whether TTO implement PBL syllabus or not. No strict enforcement. So you know... some TTOs take PBL easy. They choose not to do it. This is totally not fair for other TTOs who are willing to follow PBL syllabus. (TTO 17)*

*We need to have some sort of course evaluation to assess TTOs performance. I remember I received that in my early years at GMI. But I don't think we have it anymore. We should bring it back for PBL. (TTO 18)*

This concurs with Farmer (2004) who asserts that confidential formal evaluations of a facilitator's skills by their students allows faculty members to reflect on their role and performance as a PBL facilitator. Facilitators are evaluated at the end of the course by students and rated on their personality/behaviours and group facilitation skills. Another significant issue identified is the inadequate level of learning resources. TTOs advocated that management should fully prepare GMI in terms of internet facilities, group meeting places, classroom environment and library resources.

*The internet facilities are always on and off. Sometimes it is OK sometimes not. Students have to use their own internet data whenever the internet coverage is poor. (TTO 13)*

*We have enough machines and equipment but unfortunately there are not many rooms suitable for PBL meetings. (TTO 3)*

*We need a classroom where it is easy to arrange desks and chairs for students to form a group, sit in a circle, and face each other to discuss PBL tasks. (TTO 7)*

*I cannot find the reference books that I need for my course in the library, especially books on machining and standards. (TTO 16)*

These findings are consistent with those of van Barneveld et al. (2012) and (Montero & Gonzalez, 2009) who identified the lack of resources as a significant drawback to the successful implementation of PBL. According to Fitzgerald, Flemming, & Bayley (1999), PBL emphasises self-directed learning and this requires a full range of resources to be available if effective and efficient learning is to occur.

Finally, there was discussion about the issue of lack of recognition awarded to staff for their implementation of PBL.

*Unfortunately we don't have any incentive that rewards staff who had conducted PBL classes (effectively). How to recognise one? By monitoring staffs' work and from the evaluation sheet made by students. The incentives can boost TTO's motivation (to implement PBL). (TTO 1)*

Developing and advocating rewards for teaching is essential in valuing and sustaining the contribution of faculty to the change process (Farmers, 2004). Lai & Tang (2000) and Yusof et al. (2004) reported that, at the university level, attractive incentives and reward systems have a direct effect on staffs' willingness to spend time devising PBL courses. In addition, Wetzel (1996) asserts that, without significant reward structures, staff can view their contributions to curriculum change as jeopardizing their academic careers and discourage further involvement. Therefore, management should consider redesigning recognition and reward policies to facilitate and encourage the implementation of innovative pedagogies like PBL.

## Lack of support from colleagues

Six TTOs highlighted the challenges of not having a proper platform to discuss issues on PBL implementation. Most TTOs did not mind implementing new ideas like PBL. However, they would prefer to do it in a shared collegial atmosphere:

*I don't have any experience in teaching PBL. So, it's quite hard to work on my own. It is quite disappointing that we don't have a formal PBL support group... where TTOs can meet regularly to discuss any issues or share PBL experience. It's good if we can learn from each other. (TTO 17)*

*Actually... I heard that we do have a team called "PBL Cops". They are the representatives from each department who went for PBL further trainings for a few times. I think... they are supposed to guide and support their colleagues regarding PBL... But I haven't seen it happened. (TTO 9)*

These concepts were endorsed in Salimah & Zaitun's (2004) study. They reported that one of the essential processes of implementing PBL at their university was to form a PBL Committee in all Faculties. Committee members undertook a series of workshops and conferences to understand the PBL approach and were held responsible for disseminating and sharing their knowledge with other colleagues at the faculty level. Similarly, Irby (1996) stated that when lecturers are trained in facilitation techniques and know the basic principles and theory behind the PBL method, it becomes increasingly important for them to meet, discuss emerging problems, reflects and to share PBL best practice. These communities of practice should meet regularly as they also provide a safe environment for staff who takes risks to practice new skill. The existence of such support groups is very important in order to enhance and continuously inspire PBL facilitation informally.

New lecturers need to be able to access to more experienced PBL lecturers for informal support. This is extremely valuable as described by a TTO:

*Every time I have issues, I will refer to my senior. He knows a lot about PBL and become my point of reference. (TTO 7)*

Similarly, another TTO identified her department as one where many TTOs operated PBL purely on an individual basis. There was limited sharing of resources and classroom practice.

*Some of TTOs in my section are quite individualistic. They don't prefer to work with others. I feel upset because I have to do everything alone. It would be easier if I can work in group where other TTOs can support me, such as to design PBL lesson plans. (TTO 16)*

Likewise, another TTO observed that working with teammates is a challenge. Those who did not cooperate complained that they were too occupied with their heavy teaching load and could not commit to any PBL activities.

*Some (TTOs) don't want to cooperate when we invited them to craft PBL problems together. But they are very happy to use my work instead. (TTO 12)*

These comments reflect a desire for TTOs to be supported by their colleagues. Clancy (2005) asserts that for PBL to be successful, there would have to be commitment from other lecturers, but this might be difficult to achieve. Changing to PBL involves a large amount of personal energy and time, and some educators are reluctant to devote vast amount of

energy to it (Clancy, 2005). It is evident that one of the ways novice facilitators learn more about PBL is through regular meetings, as well as through demonstrations and written materials (Jung, Tryssenaar, & Wilkins, 2005). Therefore it is crucial that appropriate communities of practice be established to provide ongoing support outside of formal training. Such meetings provide opportunities for staff to learn from one another, and work with one another.

## Conclusion

The study reported in this paper has identified a number of issues associated with the implementation of a PBL curriculum in engineering at an institutional level or even at program level. These issues revolved around the challenges lecturers face in implementing PBL. Lecturers feel that they lack the skills to facilitate PBL effectively, and lack support from management and from colleagues. These challenges may be addressed by a managed process for developing lecturers' understanding and skills associated with the rationale, educational theory and evidence for PBL. These can also be done by giving training on curriculum design and facilitation skills, and by providing feedback and evaluating teachers' performance in facilitating PBL. In addition, the management can attend to this issues by providing sufficient facilities, by giving staff attractive incentives and rewards and finally, by establishing a PBL support group/communities to reflect and discuss reactions. This also entails the development of a culture among the staff which is supportive of a PBL approach to the delivery of GMI's programs.

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