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Students' perceptions of their initial PBL experiences in engineering education in Malaysia

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Structured abstract

BACKGROUND

Higher education in engineering and technical fields should prepare graduates to take on the increasingly challenging roles required of the engineering profession. Engineering graduates are expected to be responsible for their own personal and professional development. In view of this, the German Malaysian Institute (GMI), an established technical education provider in Malaysia, has adopted Problem-based learning (PBL) as its innovative approach. The main objective is to prepare technologists and industrial workers who are well-grounded with soft skills and abilities. These include abilities to apply knowledge, higher order thinking skills, and personal values, alongside strong hands-on and technical skills.

PURPOSE

This paper describes the implementation of Problem Based Learning (PBL) as a new approach in the context of engineering education at GMI. It provides an analysis of the first cohort of students' feedback of their initial experiences of PBL after its implementation in January 2010. The paper focuses the first years' student experiences specifically looking to better understand the ways in which they engage with PBL.

DESIGN/METHOD

A questionnaire survey was administered to 115 first year students in the Department of Industrial Electronic, after four weeks of PBL implementation in the first semester of their studies. The survey addressed the students' perspectives on PBL course content, course delivery, self-motivation and PBL assessment. Section A required students to answer using a Likert scale of 1-5 (where 1 meant Strongly Disagree to 5 which meant Strongly Agree). Section B requested open-ended feedback on PBL implementation and difficulties students experienced with PBL. The survey was conducted to evaluate and refine the process of PBL implementation at a very early stage.

RESULTS

Overall, students' initial feedback was positive and provides encouragement to continue with the PBL approach. This is despite the typical problems that student face including the challenges of working in groups, insufficient resources or insufficient time to complete the problem given. The survey results provide insights into what the majority of students recognise as the benefits of PBL especially in enhancing their critical thinking, problem-solving skills and team-working skills.

CONCLUSIONS

The findings of the survey indicated that it is clear much can still be done to make PBL a success. The Department of Industrial Electronics have taken immediate measures to address the issues raised by students. Our findings support the notion that PBL is suited to be adopted in engineering disciplines because it nurtures critical thinking and problem-solving skills which are central to a graduate's career in engineering.

KEYWORDS

Problem-based learning, engineering education

Introduction

Higher education in engineering and like technical fields should prepare graduates with appropriate proficiencies to take on the increasingly challenging roles required of engineering profession. Malaysia as with the rest of the world, is dealing with global economic challenges that require employers in the engineering sector to engage engineers who are technically competent and possess employability skills such as leadership, team-working, communication, problem-solving and critical thinking. However, several researchers in engineering education have found that the current educational systems and practices in Malaysia was unable to deliver the graduates with the necessary generic skills and employability skills needed by industry.(Nurita et al., 2007; Zaharim et al., 2008;Razak, 2008)

Accordingly, several significant studies, conducted on employability skills, in Malaysia have identified that graduating students, while technically competent and knowledgeable, lack many of the abilities required in real-world engineering, including problem-solving, oral and written communication skills, interpersonal skills and an ability to be flexible (Zaharim et al 2008;Omar et al, 2012; Razak, 2008). In particular, the study carried out by The Ministry of Higher Education of Malaysia in 2005, reported strong evidence of the lack of generic skills amongst undergraduates where the majority of the 422 surveyed employers identified that the skills most lacking were the ability to identify problems, formulate solutions, communicate effectively and work in teams. (MOHE,2006).

If these shortcomings are to be addressed, universities and technical institutions need to refine their curricula to emphasize teaching and learning experiences that develop non-technical skills aspects amongst undergraduates and abilities to be self-directed learners. One approach seen as appropriate to address the identified issue is Problem-based learning (PBL). PBL is an instructional and curricular approach which is student-centred and empowers student to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem (Savery, 2006). In a PBL setting, teachers provide students with learning scenarios which draw on real life problems which require learners to work in small collaborative groups, utilise their prior knowledge and expertise, think critically and finally, presenting their findings, whereas teacher acts as a facilitator of learning, guiding and supporting the students to reflect on the learning process. (Neufeld & Barrows, 1974)

This paper investigates first year students' responses to the initial implementation of PBL at German Malaysian Institute, Malaysia. Firstly a background on PBL in engineering education is presented as a rationale for its implementation. Then, the overall implementation strategy,Pro3-Based Learning (Pro3BL), is described. This is followed by an analysis of the students' perceptions of PBL after its initial implementation in the Department of Industrial Electronics during semester 1/2010.

Background

Problem-based learning in Engineering education

The primary aims of engineering education are "to produce broad-based, flexible graduates who can think integratively, solve problems and be life-long learners" (Matthew & Hughes, 1994). In view of this, recent evidence suggests that PBL has been at the core of significant development in engineering education(Montero & Gonzalez, 2009). PBL assists in developing problem-solving, enhance communication skills, team-work, leadership, self-directed learning and life-long learning(Montero & Gonzalez, 2009; Jones, 2006), promoting deep approaches to learning instead of a surface approach (Biggs, 2003), and enhance knowledge and critical thinking ability (Masek & Yamin, 2011).Research findings also indicate that important principles of learning such as motivation, relevance, practice, active-learning, and contextual learning operate more extensively in a PBL environment than in traditional curricula (Guedri, 2001).In addition, PBL is applicable to engineering since it is acknowledged to help students to acquire scientific and technical knowledge and to develop

professionally valued skills and attitudes without adding extra subjects. (Roberto de Camargo Ribeiro, 2008).

PBL was originally implemented in medical schools in the late 1960s and has subsequently been adapted to other academic disciplines, including engineering (Boud & Feletti, 1997). Specifically, Aalborg University in Denmark implemented a PBL curriculum in 1974 (Kolmos, Fink, & Krogh, 2004). Woods applied PBL in chemical engineering programs at McMaster University in the early 1980's (Mills & Treagust, 2003). In Belgium, comparison between a traditional curriculum in engineering and a PBL curriculum being conducted since 2000, identified that PBL students improved their skill levels significantly compared to students from lecture-based curricula. (Du, de Graaff, & Kolmos, 2009). At Monash University, Australia, Hadgraft initiated PBL in civil engineering degree courses by incorporating PBL into second year Computing and Surveying ; a third year course in Systems Engineering, a post-graduate course in Surface Water Modelling and Yield Hydrology (Hadgraft, 1993; Hadgraft & Paget, 1990) and a fourth year course in Civil Engineering Computing (Hadgraft, 1997). In Singapore, both Temasek Polytechnic and the Republic Polytechnic have implemented PBL curricula for computer, electrical and industrial systems engineering diploma programmes. (Northwood, et al., 2003).

Likewise, in Malaysia, there has been increasing interest in implementing PBL in institutes of higher education based on the perception that it assists students acquire the necessary technical knowledge and transferable skills (Said, et al., 2005). For example, the move to implement PBL at the University Teknologi Malaysia (UTM) was initiated in 2002 and tests to evaluate PBL effectiveness were conducted in the first semester of 2003/04 in the Department of Chemical Engineering (Yusof et al., 2004). In addition, an initial attempt to implement PBL within engineering syllabi in the University of Malaya commenced during 2003/2004 session (Said et al., 2005). Moreover, the Universiti Tun Hussein Onn Malaysia (UTHM) adopted PBL in 2005 in the Faculties of Civil and Environmental Engineering, and Electronics and Electrical Engineering (Salleh et al., 2007). Similarly, the Universiti Kebangsaan Malaysia (UKM) introduced PBL in engineering statistics in the second semester of 2007/2008 to develop students' generic skills. (Nopiah et al., 2008). In 2009, Polytechnic Port Dickson introduced PBL in Electrical Engineering subjects. (Krishnan & Ruhizan, 2009). What is evidenced above is the widespread adoption of PBL in engineering education in Malaysia as well as many other countries. However, most of the PBL initiatives have been within a specific program of study or course, rather than full institutional adoption. The next section describes the full adoption of PBL in engineering education at German Malaysian Institute, Malaysia.

Problem-based learning at German Malaysian Institute

The German-Malaysian Institute (GMI) was established in 1991 as the result of collaboration between the governments of Malaysia and Germany. GMI is a technical training centre with its main objective to meet the demands and needs of domestic industrial sectors by producing graduates suitably equipped for manufacturing and engineering.

In view of the challenges and to meet the urgent demand in Malaysia for skilled engineers and technologists, GMI introduced a new approach (called Pro3BL) in January 2010 to complement the existing training approach that emphasized workplace competencies. Pro3BL is an acronym for 'Problem, Project, Production-Based Learning'. Pro3BL is an innovative and integrated education strategy in a student-centred learning environment that allows for flexible adaption of guidance through problem solving, project works and real life industrial activities (Ngan, 2010). The educational outcomes from the Pro3BL curriculum are intended to produce workers who are capable and demonstrate the range of competencies required to stay competitive in the current job market. Figure 1 shows the Pro3BL model with its education outcomes.

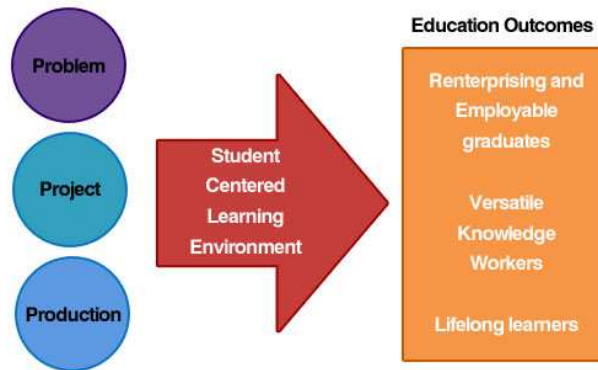


Figure 1: Model of Pro3BL with the education outcomes (Ngan,2010)

GMI offers three years Diploma Programs in the field of Industrial Electronics and Production Technology. The Pro3BL curriculum structure, founded on PBL, is implemented at an early stage of the learning process, namely the first two years of Diploma Programs. This approach is consistent with Hadgraft's (1993), approach where engineering students were involved in the process of engineering from the earliest stages in their course. The first years of engineering programs can be used for general problem-solving, concentrating on the problem-solving processes, understanding group interactions and developing communication skills (Hadgraft & Paget, 1990). At GMI, Technical Training Officers (TTO)/lecturers act as a learning facilitators by providing substantial scaffolding and guiding the students in learning and developing strategies to respond to the challenges presented by PBL.

Project-based learning is the strategy deployed in Year 1 and Year 2. It is an instructional method centred on learners that organises learning around projects (Thomas,2000) or a desired end-product (Savery, 2006).For example, students may be required to complete a design, a model, a device or a computer simulation. TTOs act as coaches who provide expert guidance, feedback and suggestions to achieve final products. A number of researchers have reported that project based learning has encouraged students to cohesively conceptualise engineering fundamentals to develop comprehensive acceptable solutions for engineering problems(Lemckert, 1999; Woods et al. 2000;Mills & Treagust, 2003). In addition, students become more engaged and motivated, which naturally leads to higher levels of learning, developed self-reliance and improved attendance (Thomas, 2000).

In Year 3, problems increases in complexity whilst TTO scaffolding decreases, culminating in a final year project which involves production-based learning. Production-based learning combines education and production in teaching and learning environments (Salam et al., 2011; Ngan, 2010). Students experience real-life industrial activities using multi-disciplinary knowledge skills and attitudes to produce products and services. Students are presented with open-ended design tasks based-on real-life engineering problems according to their specialization. They work in groups to define problems, brainstorm ideas, debate solutions, collaborate, plan and schedule tasks, make decisions, self-evaluate, design and produce a final product that meets industry standards.

Students' reaction to PBL implementation

The Department of Industrial Electronics at GMI conducted a survey of semester 1 students four weeks after the pilot implementation of PBL (January 2010). The objective of this survey was to evaluate and refine the process of PBL implementation at a very early stage. The questions in the survey addressed students' perspectives on the following areas; PBL course content , PBL course delivery, self-motivation and PBL assessment.

Section A of the survey required responses to a Likert scale of 1 – 5 (where 1 meant Strongly Disagree to 5 which meant Strongly Agree). Section B requested comments and feedback

based on students' answers in Section A. One hundred and fifteen students of six semester 1 classes took part in the survey. Some of the significant results are tabulated in Table 1.

Results and discussion

Overall, 22 items were investigated. This paper focuses on the significant findings. First of all, as shown in Table 1, the responses in PBL course content are encouraging where 82.2% of students chose "agreed" or higher in response to the question about whether TTOs were effective in orienting them with an introduction to PBL. Since PBL was a new approach, orientation sessions were seen as crucial to ensure students understood PBL. Seventy-two per cent of students chose "agreed" or higher, that problem statements are well-presented.

Table 1: Results of the survey

Components	Percentage					MEAN SCORE
	S.D(1)	D(2)	N(3)	A(4)	S.A(5)	
A. PBL Course content						
TTO gives PBL orientation at the beginning of the module	0	6.7	11.1	58.9	23.3	3.99
Problem statements are well-presented e.g using handout,slides etc	3.3	3.3	21.1	50	22.2	3.85
B. PBL Course delivery						
Number of students per group is practical (logical)	0	2.2	14.4	57.8	25.6	4.07
Group task and discussion help you to understand the topic clearly	10	13.3	15.6	51.1	10	3.38
Tasks and presentation are well-distributed among group members	0	5.6	36.7	52.2	5.6	3.58
Time and duration given per problem statement is sufficient	17.8	17.8	25.6	32.2	6.7	2.92
TTO facilitates the group discussion	4.4	6.7	18.9	51.5	18.9	3.74
TTO gives comments and feedback	2.2	7.8	7.8	45.6	36.7	4.07
Facilities and resources are adequate to complete PBL tasks	8.9	16.7	28.9	33.3	12.2	3.23
C. Self-motivation						
Your mind is critically challenged during PBL sessions	2.2	5.6	18.9	51.1	22.2	3.86
You are free to give ideas during group work, discussions and presentations	2.2	5.6	8.9	47.8	35.6	4.09
D. Assessment						
Assessments given is fairly evaluated	2.2	7.8	47.8	37.8	4.4	3.34
Test questions are clearly understood	6.7	8.9	56.7	23.3	4.4	3.10

Problem statements can be presented in various formats such as written scenarios, case-based, events, audio, video, physical samples and laboratory worksheets. (Masek & Yamin, 2010). The problem format is selected according to the suitability of the topics, objectives and learning materials that are available at GMI. Most importantly, the method of problem-delivery must be suitable and understandable by the students.

One of the characteristics of PBL is that learning is best accomplished in small groups to foster the development of collaboration skills. (Barrows, 2009). In addition, critical thinking can be encouraged and arguments developed in small group tutorials. (Neufeld & Barrows, 1974). Similarly, Krishnan (2009), stated that learning in teams is an integral part of PBL and it is one of the most challenging arrangements for many students and facilitators. The survey indicated 83.4% of students chose "agreed" or higher that the number of group members (four or five) was practical. The students benefited from the opportunity to work in teams whereby 61.1% chose "agreed" or higher in response to group work. They observed that discussions helped them to understand topics more clearly. Team discussion helps students to elaborate on their knowledge (Schmidt, 2009). It permits students to build up the abilities necessary to be responsible for their own learning. The 38.9% who did not agree gave the following reasons for their dissatisfaction; that each member should have their own task and not be required to work collaboratively, thus removing the need to depend entirely on other members to complete the tasks. Students also expressed concerns about members who did not have a teamwork spirit, who are difficult to cooperate with and did not commit to the tasks given. Similarly, only 57.8% chose "agreed" or higher that tasks and presentations were well distributed among group members. The majority commented that some members are passive and did not contribute equally. Students argued that if everyone cooperates, productivity increases, thus time taken to solve problems decreases. For this reason, the appropriate mix of students to form a group is crucial for PBL. (Yeo, 2005). Accordingly, some students expressed their belief that group membership should remain constant for all courses throughout a semester to avoid conflicts of opinion. Some suggested changing group membership so they could experience working with different team members. Overall, there were mixed feelings about this issue.

There are concerns that PBL makes significant demands upon student time, and that there would not be enough time to fully cover the syllabus (Yusof et al., 2004). Approximately 61.1% did not agree that there was sufficient time to complete PBL tasks. Students identified problem identification as the most difficult stage in the PBL process. Engaging in problem solving activities was time consuming and full of uncertainty. As a result, they had difficulty in completing the tasks on time.

Facilitation of students' activities and feedback from TTO at the end of a session is critical in ensuring PBL approaches are successful (Barrows, 1992). From the survey, 70.4% chose "agreed" and higher in response to TTOs facilitating group discussion whereas 82.3% chose "agreed" and higher that TTOs gave feedback and comments during PBL session. These findings are indeed very encouraging as they indicate that the TTO played their roles quite effectively, changing from being a teacher to a facilitator. Those who did not agree that this was their experience commented that some TTOs did not explain tasks clearly, did not provide enough direction, or provide guidance and feedback sessions.

More than half of students (55.5%) felt that facilities and resources were inadequate to complete PBL tasks. With PBL, the learners engaged in self-directed learning requiring numerous trips to the library in search of reference books and internet facilities. Students lamented the lack of meeting places for their discussions, the lack of reference books, journals and wi-fi/internet coverage areas.

One of the benefits often claimed for PBL is an improvement in students' higher order thinking skills, especially their reasoning skills (Savery, 2006). It is also effective in targeting specific learning domains, such as critical thinking ability (Masek & Yamin, 2012). This is evident from the data where 73.3% of students chose "agreed" or higher that PBL challenged

them to think critically. Of the 27.7% who did not agree, some commented that PBL was a culture-shock to them. Since students were all new to semester one's subjects (eg Electrical Principles), they expected their teachers to explain the content to them first. Instead they were asked to perform self-directed learning, leaving them confused and frustrated. In reply to another statement, 83.4% of students were able to express ideas freely during group work, discussions and presentations. These results provided staff with evidence of PBL's effectiveness in developing students' reasoning strategies as well as in enhancing their confidence to speak out in multi-disciplinary team environments. Students commented that PBL required them to learn how to think, to problem solve and to learn independently. Those who disagreed (16.6%) mentioned that they were not good in English and this inhibited their communication specifically when the need to express ideas in class was required.

According to Savin-Baden,(2004), assessment is one of the most controversial issues in PBL because it is the most important indicator for validating its effectiveness. In this area, only 42.2% chose "agreed" or higher in response to the question whether the assessments given were fairly evaluated, whereas only a 27.7% clearly understood the test questions. The majority of students did not comment on why they rated assessment this low. This may be due to the fact that PBL had only been implemented for four weeks when the survey was conducted and assessments were not being conducted yet. However, again most students expressed concern about understanding and communicating in English. They felt they could not express themselves well during presentations, resulting in low grades. Students needed support and understanding from TTOs. This is an area for future consideration.

Findings and responses

To bridge the gap between technically competent, knowledgeable graduates and graduates who possess excellent non-technical skills, GMI has taken the initiative of introducing Pro3BL. The study reported here has provided some valuable insights into the effectiveness of the implementation of the Pro3BL initiative. The Department of Industrial Electronics has responded to the issues raised by students, and further evaluation of the effectiveness of the initiative will provide further insights to this approach.

In terms of time constraints, many problem statements and problem scaffolding have been reduced and re-crafted to ensure students have sufficient time to complete their tasks. Most of the subjects have been implemented using a hybrid model of PBL approach, (with a mix of traditional lectures and PBL activities). Necessary infrastructure such as free wi-fi has been installed or upgraded. Adequate meeting areas and reference materials have been made available. Libraries' opening hours have been extended until 10pm at night and are now open on Saturday as well. Laboratories have been equipped with additional components and equipment to be used for practical classes in PBL exercises. Open discussions are held regularly among TTOs to identify and address PBL implementation issues from time to time. Assessment structures have been uniformly practiced to ensure students are satisfied with PBL grading systems.

Conclusion

Overall, the findings from the initial PBL implementation have been very positive and have provided encouragement to continue the Pro3BL approach. The majority of students recognised the benefits of PBL especially in enhancing their team working skills and dealing effectively with disagreements and conflicts of opinion. In fact, these are skills that are critical in the workplace in these times of tight resource allocation and competitive markets (Northwood et al., 2003). The study reported here is the preliminary phase of comprehensive investigation undertaken by GMI to improve PBL initial implementation. It provides the starting point for the first named author's research higher degree studies. It presents interesting insights for the development of the subsequent years of the program's curriculum and teaching approaches. Therefore, future phases of the study will provide a more significant understanding of the issues and benefits to be gained by GMI's initiative.

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