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FRAMEWORK FOR PROJECT-BASED LEARNING (PJBL) IN PROVIDING REAL WORLD EXPERIENCE FOR ELECTRICAL ENGINEERING STUDENTS

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Universities nowadays keep receiving complaints from the industry regarding the capability of engineering graduates to work. This problem is actually caused by the lack of exposure to the world of work given to the engineering students by the university. Therefore, it is imperative to give and expose the engineering students towards real world experience. Project-Based Learning (PjBL) is a teaching method that is appropriate to be implemented on engineering students. Hence, this research was conducted to investigate the effectiveness PjBL in providing real-world experience to electrical engineering students based on the opinions and perceptions of students and lecturers. This study also intended to develop a framework of PjBL that can be used to as an effective teaching method in order to provide real world experience to the electrical engineering students. This study used a qualitative method in which the data were collected by using interviews and observations. The respondents for this study were the students and lecturers that were involved in the PjBL from two universities in Malaysia. The results of this study found that the students and lecturers agreed that PjBL is an appropriate teaching method to provide real-world experience to students, where the students were exposed to the actual practices of an engineer in the industry and also able to learn the skills needed by engineer. Therefore, this study suggests that the proposed PjBL framework can be used to teach the engineering students in order to expose them with real world experience.

Keywords: Project-Based Learning, Real World Experience, Electrical Engineering Students.

1. INTRODUCTION

Experience is a good teacher for every person that lives in this world. Experience provides people with valuable knowledge that cannot be bought or learned theoretically. In order to get the knowledge, people must undergo the experience by themselves. In the academic context, providing experience to the students is a good way to teach them as they are able to see the application of the knowledge they learned. According to McLaughlin (2010), most of the undergraduate students do not have any working experience and they do not know what is happening in the real world. Thus, it is imperative for the university to provide the students with significant and valuable experience to the students that can enable them to imagine what the real world looks like.

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Providing real world experience to the students is an alternative method that should be promoted (Rogers-Chapman and Darling-Hammond, 2013) among lecturers in the university rather than implementing wholly traditional methods throughout four years of study in undergraduate engineering programs. Generally, real world experience's purpose is to expose the students to the real practice of certain professions in their discipline. Moreover, the experience will also enable the students to relate the classroom experience towards external situations. In other words, the real world experience is to expose the students to the learning situations that replicate the situations and issues faced by the engineers in the real world. But *et al.* (2007) stated that real world experience can be defined as learning experience that involves internship, study trips, fieldwork, case studies, Problem-Based Learning (PBL), Project-Based Learning (PjBL) and other methods that can relate the classroom context towards real world practice.

This statement is supported by Kolmos, (2009), which stated that the solution for the new requirement of skills of undergraduates in engineering education is by implementing problem-based learning (PBL) or project-based learning (PjBL). Nonetheless, PjBL is a more suitable method in exposing the engineering students toward real world experience because PjBL was established in the engineering field to provide experience for engineering students (Perez *et al.*, 2010). Furthermore, project works are able to retain students in engineering programs (Bates, Krapcho and Orantes, 2014) and are able to improve their motivation to learn future material (Williams and Williams, 2011).

2. BACKGROUND OF RESEARCH

To become an engineer is not difficult, but to be a competent and professional engineer is one tough job. In order to become one, Hasna (2008) reported that an engineer must contend with endless societal and technological transformation due to the industry's rapid development. Engineers must know how to adapt themselves so that they always become productive in any kind of situation. According to ASEE (2003), an engineer is defined as "problem solvers, people, who search for quicker, better, less expensive ways to use the forces and materials of nature to meet tough challenges". In today's world, society has put a lot of burden on engineers where people are expecting the engineering world to provide creative and innovative solutions in order to make their life easier and comfortable (Clark and Andrews, 2010). As engineers, they need to fulfil the humans' needs, but at the same time they must put environment and nature into consideration. They cannot sacrifice the nature and environment in order to satisfy human desire. Thus, code of conduct or engineering ethics is established in order to provide guidelines to engineers. In other words, engineers must have good problem solving skills and ethics, which are part of non-technical skills.

Nonetheless, universities fail to provide engineering undergraduate students with appropriate education, knowledge and skills which are sought by current industries and are unable to prepare them adequately for professional practice (Berglund and Heintz, 2014; Nair and Patil, 2008). Lowden *et al.* (2011) further added that universities and industries have different views and perspectives of skills needed by graduates. In addition, most universities prefer to teach and focus on academic or theoretical knowledge as they see only little value obtained by the students through the real world experience (Robles, 2012). Lecturers also prefer their students to do academic research and give them a lot of assignments that are mostly related to enhance their theoretical knowledge. Therefore, discrepancies emerge between what educations provided and industry needed (Arnold, 2010).

There has been a lot of engineering graduates, no matter from electrical, mechanical, civil and others, working with companies such as banks, restaurants and companies that not related to engineering. Engineering graduates also commented that there were little or no relationship between what they have been taught in universities and what they have done in the industries. These phenomenon shows that there is a problem in engineering education and review on engineering education must be done (Onwuka, 2009). On the other hand, previous studies also found that the engineering students drop-out rates also high compared to students in the other field due to complexity of engineering subjects (Alting *et al.*, 2012; Dekker, Pechenizkiy and Vleeshouwers, 2009). In other words, the students were not able to understand the subjects, which lead to decrement of motivation to learn. In order to solve this problem, engineering students need to be exposed to the real world experience in order for them to get better understanding on every knowledge they learned in the class (Walker, Stewart and Panuwatwanich, 2014). Furthermore, real world experience also promotes in-depth understanding and students easily recall what they have learned previously.

3. METHODOLOGY

This research conducted was a qualitative research method, which was based on interviews and observations. Population for this research consists of first year electrical engineering students and the facilitators from two different universities that implemented PjBL in their engineering curriculum, which were University A (UA) and University B (UB). The data for this study was collected until the data was saturated for both interviews and observations. For the interview method, five students and three lecturers were interviewed in UA, and six students and three lecturers were interviewed in UB. As for the observation method, the researcher conducted observation during the lecture sessions and group discussions. Three groups were observed in both UA and UB for the whole semester. In this study, the students were required to undergo this subject for one semester, which they

were required to complete a project in a team. This study was conducted in two phases, where in the first phase the researcher conducted observations for fourteen weeks and in the second phase the researcher conducted interviews. Figure 1 below shows the phases for this study.

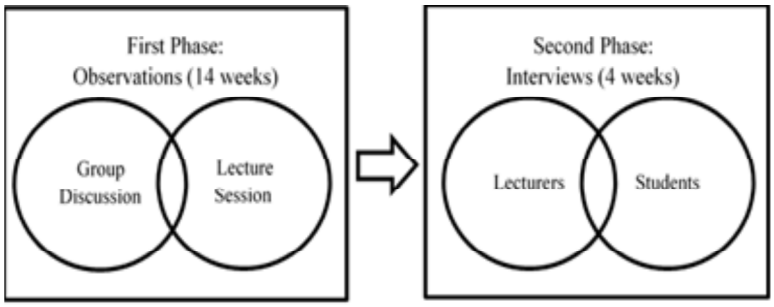

Figure 1: Research Phases for the Research

4. RESULTS

The results from engineering students from both universities show that the students feel like they are working like a real engineer during the project work in PjBL method. The results are also in line with the results that the researcher obtained from the facilitators that taught PjBL subjects. Based on the findings from the interview, there are four main themes that can be made, which are shown in figure 2 below. The first theme is multidisciplinary team, which make the students feel like they are working like a group of engineers on a project since all of them are from different fields. The students claimed that they were working with other students from chemical and mechanical engineering to make the project. The students confessed that it was very hard for them in the early phase as they needed to share and deliver knowledge to other people from different backgrounds. Nonetheless, the experience working in a multidisciplinary team were able to give them opportunity to develop their skills and give them exposure towards the real practice of engineers.

Another theme for these findings is the real world project task that the students needed to do. All of the students express their excitement doing this project by stating that they can see the application of their knowledge on a real project for a real world. Furthermore, the students are able to relate the project towards the current engineering issue. This issue was actually referred from National Academy of Engineering and the facilitators pick a challenge related to solar energy. The students claimed that they felt the pressure working on the project since they need to fulfill the criteria and must complete the project within the budget, which was RM 150 for each team.

The third theme for these findings is that the students were taught by engineer himself. The findings found that the students felt like they were working like a real engineer who is under a supervision of a boss. They were facilitated by lecturers and an engineer for the whole semester. They needed to make a proposal presentation for their project in front of the engineer and they needed to deliver every detail to him in term of materials, budgets, planning, work distribution and Gantt Chart. Moreover, they also needed to make weekly presentations to the engineer in order to inform the progress regarding their project.

The last theme obtained from the students is industrial visit. The students stated they were having opportunities to visit a few engineering-based industries. They stated that they were able to see how the actual engineer works in the industry and what kind of work that they actually deal with. The students further added that they were able to obtain the new experience as they were able to prepare themselves to be an engineer in the future. The industrial management team also gave the students a talk regarding the work they do in the industry and the students were also able to listen to experience sharing by some of the senior engineers at the industry.

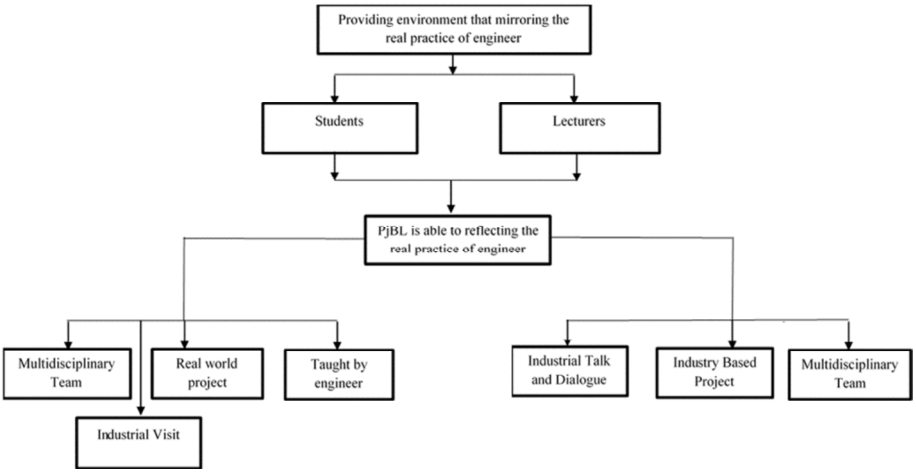

Figure 2: Themes Generated from the Interviews with Participants

As the results from the facilitators, three themes can be generated from the interview. The first theme is industrial involvement. The facilitators stated that a dialogue session will be held once a year between the school of engineering and several industrial representatives, which mostly consist of senior engineers. The purpose of the dialogue session is to ensure that the faculty and the industries are on the same page in terms of skills required to be equipped for the engineering graduates. Moreover, the faculty are also able to get a lot of input from the industries

regarding the implementation of project works for the students. These findings cannot be obtained from the students as they were not involved during this dialogue session.

The second theme is industry based project, which was the project that needed to be done by the students during PjBL subject. The facilitators claimed that every project was based on the discussion done between school of engineering and the industrial representatives. Most of the projects were actually referred to the Engineering Grand Challenges, which is proposed by the National Academy of Engineering and based on the concept of Conceive, Design, Implement and Operate (CDIO). The purpose of the real world projects given to the students is to expose the students to real world experience. By doing this, the students will be able to prepare themselves to face any challenge and pressure in the future. This theme is the same as the theme obtained from the students.

The last theme obtained from the facilitators is also the same theme obtained from the students, which is multidisciplinary team. The facilitators stated that it is important to provide the students with a multidisciplinary environment as the industry nowadays require the engineering graduates to work in diverse teams. Moreover, this whole new experience will teach the students how to communicate and exchange ideas with people from different backgrounds of knowledge. They also added that this experience is important to be given and exposed to the engineering students in order for them to prepare mentally and physically on what they are going to do as engineers in the future.

5. DISCUSSION

Based on the findings, a framework for PjBL has been established in order to provide real world experience to the engineering students as shown in figure 3. Three main elements have been identified from the collected data, namely real world project, multidisciplinary team and industrial involvement.

5.1 Real World Project

Real world project is the main criteria in providing real world experience for the students since the students require project-related work in PjBL. It is the real existing project or application that is performed by the engineers or it can be based on the current or future issues that are faced by engineers in the industry (Blicblau and Richards, 2012). Based on research conducted by Lanigan (2009), engineering students will have higher motivation to learn if they are exposed to project-based experience compared to students without the same exposure. He further added that project-based experience must relate to the real world context in order to provide significant impact on engineering students' motivation because through the real world project, the students are able to see the reflection towards real engineering practice. There are two ways to provide a real world project for the engineering students:

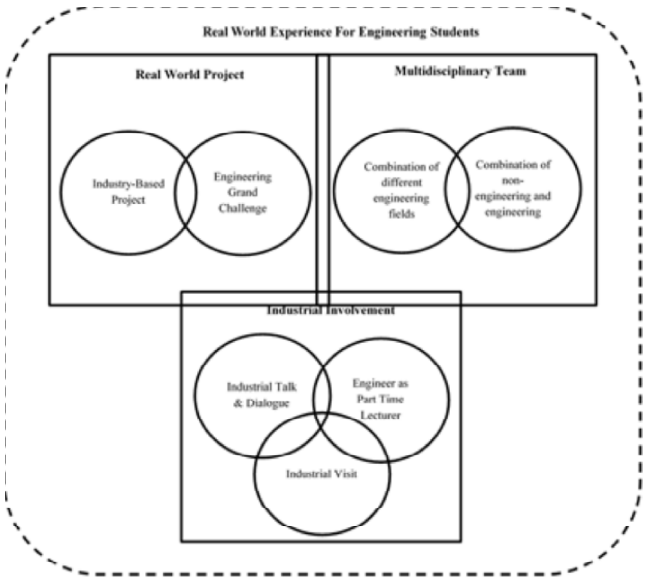

Figure 3: Theoretical Framework for PjBL in Providing Real World Experience for Engineering Students

1. Engineering Grand Challenges

Provided by a team of experts made up of researchers, lecturers and engineers from the National Academy of Engineering. These challenges provide a lot issues that need to be solved by the current engineers. By doing this, the students will be able to see the application of their knowledge and they will indirectly appreciate the knowledge that they have.

2. Industry Based Project

Projects for the students can be provided by the industry as well. The projects can be obtained through collaboration between universities and industries. This collaboration will be able to give benefits for both side since the faculty will be able to produce better engineering graduates, whereas the industry will be able to recruit and hire the graduates from the university that equipped with the required skills.

5.2 Multidisciplinary Team

Working in a multidisciplinary team is one of the main requirements for today's engineers (Ahmadian, 2011). In order to become an excellent engineer, the students must be able to have superb social skills in order to work within a team that consists of people from several of fields. And of course, engineers not only work with other engineers, but they also need to work with people from other professions

such as lawyers, salesmen, contractors and many others (Strong, 2005). Thus, by providing the students with a multidiscipline working environment, the students will be able to develop this critical skill for their future career (Brown and Alejandre, 2011). Moreover, the students are able to integrate their knowledge from various fields of knowledge into one single project. Through multidisciplinary approach in PjBL, the students will get a better view on real engineering practices. Moreover, it can train the students in working with people from fields other than their own because it will provide different team environment. There are many real world projects that apply multiple disciplines of engineering on a single project. In a multidisciplinary team, the students will be able to learn new knowledge from other fields as well and thus, develop their problem-solving skills and teamwork skills (Ponsa *et al.*, 2015). There are two types of multidisciplinary team that can be used in PjBL:

1. Multidisciplinary team consists of a variety of engineering fields

The team is a mix between different engineering fields, which can be two or more fields in one team. Through this approach, the electrical engineering students will be able to learn how to collaborate with the engineering students from another discipline and at the same time, integrating their knowledge into one. This approach gives full advantage to every engineering student to develop their non-technical skills.

2. Multidisciplinary teams consist of engineering and non-engineering fields (Lattuca et al., 2011)

This approach also can be done by mixing electrical engineering students with students from non-engineering fields such as students from management, financial, science or physics. This approach also provides a good practice for the students as it mirrors the practice of engineers because engineers also team up with different kinds of people from different kinds of profession.

5.3 Industrial Involvement

Moreover, the learning process in PjBL should involve the industry as well. Since there were comments from the industry regarding the failure of universities in preparing their students with what the industry requires (Arnold, 2010), the university or faculty needs to initiate collaborations with the industry so that they are informed of the skills that should be nurtured in their students since they are the products that the industry will seek for when the students graduate. By involving industry in PjBL, it will bring a lot of advantages to the students and the faculty and university as well (Harmer and Stokes, 2014). One of the advantages for the students is that the students are kept informed of the current issues that engineers are facing in the industry and it also can boost students' motivation (Lockrey and

Bissett Johnson, 2013). Moreover, the students are also able to know how real engineers work on projects. As for the faculty or university, they can ensure the content or the syllabus for every subject that they offer is still relevant in current technology. In addition to that, the university is able to keep pace with the rapid changes that keep on going in the industry. There are several ways to involve the industry in the curriculum or PjBL:

1. Industrial talk and dialogue

In this approach, the university needs to invite engineers from the industry to give a talk about the current situation on the engineering industry (Nordin, Zainal and Hussain, 2012). In order to get students' full attention during the industrial talk, lecturers may ask the students to make summary report on the industrial talk. Moreover, lecturers can also create test, which is prepared by the engineers, in order to make sure the students are able to understand and listen to the industrial talk. University also need to make a dialogue session with industry where the both sides can create a lot of collaborations in order to produce better engineering graduates (Mead, 2015).

2. Industrial visit

The students go out on a trip to any engineering industry that is related to the students' field. Through this approach, the students are able to get a better view on how engineers work while in the industry (Tirunelveli *et al.*, 2013). Moreover, the students are able to see the technology and the machines that are currently used by the industry and the engineers (Sen, 2013). The students can also have the industrial talk while doing the visit.

3. Engineer as part time lecturer

Engineers act as facilitator and supervisor as well during PjBL session. This may be the best way to involve the industry in the curriculum. The faculty or university needs to appoint or hire an engineer as a part time lecturer to be fully involved in PjBL learning process. It brings a lot of advantages to the students because the students will be able to see everything they learn in the engineering context based on the engineer's experience. Moreover, the students will be able to learn about engineering ethics, engineering reports, how to make a professional presentation and are also able to get a supervision from the engineer on their project progress. Thus, the students will be able to get a good practice and develop their non-technical skills before the students graduate.

6. CONCLUSIONS

University needs to put a lot of emphasis on the development of skills of engineering students since the skills required by the industry nowadays are not the same as

decades ago. The engineering students need to be exposed to the real world experience, since a lot of engineering graduates are unable to work immediately in the industry due to lack of exposure towards their future profession in the world of work. Thus, university needs to use a different approach in delivering the real world experience, which is by using PjBL as a teaching method for engineering students.

This paper proposed a framework for PjBL in order to deliver a real world experience to the engineering students. Thus, university is recommended to apply the proposed framework of PjBL as it is able to provide significant experience for the students to develop their skills in the real context of engineering. This framework can be used for further study to investigate the development of technical and non-technical skills or improvement of knowledge retention for the students.

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