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A Review of Problem-Based Learning in Electronic Engineering Course

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Abstract
Industrial Microcontroller is an area which is widely used worldwide particularly in the industry. The Microcontroller is also one of the subjects offered at universities and colleges of Science, vocational, engineering and technology. Normally, the learning method practiced in this subject is by referring to the related handbooks and textbooks. This method requires the students to memorize the tough technical terms, and typically students neglect the actual purpose of the terms used in Microcontroller subject. The aim of this paper is to observe the implementation of Problem-Based Learning (PBL) in engineering field in order to promote lifelong learning in conveying knowledge about engineering.
Keywords: Microcontroller, Engineering, Problem Solving skills, Problem-based Learning

Introduction
Since microprocessors have become an integral part of the engineering curriculum over the last few decades, many teaching methods are particularly introduced (Strangio, 1988). One of the key features in teaching method is hands-on training in laboratory to nurture practical application together with theoretical understanding of microprocessors (Hedley & Barrie, 1998). The microprocessor courses are taught in computer science courses or in electrical engineering departments (Hamrita & McClendon, 1997). In general, students will acquire more knowledge and skills as they take an active role in both practical and theoretical learning. Therefore, the learning method for Microcontroller subject should be taken into account so that students not only gain theoretical experience, but also include practical insights learned from lectures. Through practical training, students can gain early exposure in Microcontroller learning, and also gain a better understanding through the use of high technology in

Microcontroller systems as well as complementing theoretical knowledge of student (Ajao, Agajo, Kolo, Adegboye, & Yusuf, 2015).

Programming in Microcontroller is a logical application specified in a format that the machine can understand. This logical application needs to be clear so that this process can change the program by using the programming language. Hence, students need to master the basic theories learned in previous learning to strengthen their knowledge in the subject of Industrial Microcontroller. In this study, the theory refers to all relevant knowledge and information related to the Industrial Microcontroller which involves mastery of logic basics, Boolean equations, Electronic Digital subjects and basics of building a circuit, use of 8085 Microcontroller and their easy program such as LED blinking. This theoretical lesson of Industrial Microcontroller given in class needs to be mastered by all students for easy application in practical class

The practical process for this subject is for the students to start the program by asking questions, designing the circuit to the component based on the instruction, building the program and finally conducting tests on the circuit. The software of programming language involves a lot of problem solving skills and requires higher understanding (Rockland, 1999). Accordingly, the teaching and learning method required in C Language Programming and Setup Language can incorporate theoretical and practical elements to produce students who master the problem solving skills and can apply what they have learned in real life (Yeong, Abdul Rahman, & Su, 2013). Hence, the teaching and learning method using the Problem Based Learning (PBL) approach is the key to increase the interest and motivation to continue learning, analyzing, solving problems, and improving critical and creative thinking skills.

PROBLEM BASED LEARNING (PBL)

PBL in Engineering /Microcontroller Subject

Effective learning is linked to the ability of students to explore, investigate, solve problems and think critically. The student-centered learning method has earned consistent attention towards the learning needs of 21st century that foster active and self-learning (Bradley-Levine, 2014). One of the lessons which emphasize student-centered learning features is Problem Based Learning (PBL). PBL is an effective student-centered approach in improving the quality of learning (Looi & Seyal, 2014), promoting active learning (Asad, Iqbal, & Sabir, 2015), enhancing deep understanding of the subjects (Dolmans, Loyens, Marcq, & Gijbels, 2015) and encouraging self-learning (Leary, 2012; Hsu, Yen, & Lai, 2016). PBL was first developed in the mid-1960s in medicine field which aimed at closing the gap between what was learned in school and relevant requirements for future professions (Sofie, Kirschner, & Fred, 2011). PBL aims to help students developing a flexible and broad base knowledge (Gabb & Vale, 2001), fostering collaborative skills (Sellnow & Ahlfeldt, 2005) and developing effective problem solving skills.

Therefore, the PBL method is very effective in delivering technical knowledge (Tse & Chan, 2003). Through this method, students have the opportunity to practice self-learning techniques which are an important aspect in their future career. In addition, they can enhance their learning capabilities through learning in a collaborative environment within the group (Tse & Chan, 2003). The PBL curriculum can support student learning in the Microcontroller subject

(Hedley & Barrie, 1998). It also becomes a center for engineering education, particularly in relation to the transformation of new system designs to concepts and technologies by introducing relevant specialties (Striegel & Rover, 2002).

In addition, the PBL method implemented in the Microcontroller subject enables students to build their own real-world understanding and knowledge through the experiences of students during a learning session (Uden & Page, 2008). The use of the PBL method in hands-on activities in laboratories is also a new approach indicating a shift from traditional didactic teaching where students are fully responsible for the learning process and build knowledge with minimal guidance from teachers (Kim, 2012; Mohamad, Rahim, Mohamad, & Faizan, 2012). Practical activities in laboratories are traditionally important in engineering and play an important role in stimulating interest, improving student motivation in learning, assisting students to deepen their understanding on theory through practical activities, giving students the opportunity to work together to analyze and solve problems in learning, and developing skills and professional attitude to engage in engineering jobs (Clara Davies, 2008).

Therefore, practical learning or hands-on for Industrial Microcontroller subject through PBL methodology can enhance student learning skills, provide self-confidence in any Microcontroller simulation and embedded the design system. According to Kim (2012), the PBL methodology motivates students to actively engage and focus on their learning. The author also stated that 90% of students have agreed or strongly agreed that they understood the structure and function of the Microcontroller, while 83% of other students claimed that they were able to design embedded systems in the Microcontroller course. This experience can guide students to create an embedded system from an easy to complex program code, and build a unique and easy single system for industrial and research applications.

With regard to that, the PBL method in engineering field of the Industrial Microcontroller benefits the students as follows (Table 1):

Table 1. Advantage of PBL

	Advantages of PBL	Reference
i.	Help students to become more independent to learn new knowledge without relying on others (students should think like a professional engineer who can ask good questions, and seek good and reasonable answers quickly)	(Cubero, 2015)
ii.	Encourage Self-Regulated Learning (SRL), which is self-learning for students to build their knowledge and skills without the help of others or trainers	(Tse & Chan 2003)
iii.	Help students to gain enough knowledge, skills and confidence to identify and solve their own problems, design the circuit with their own efforts, summarize the questions studied and develop a reasonable solution that can be tested by the students	(Striegel & Rover, 2002)
iv.	Provide an environment (complete laboratory) that encourages students to solve problems creatively, which requires minimum supervision by lecturers	(Kim, 2012; Mohamad et al., 2012)
v.	Build self-confidence and enthusiasm by ensuring a simple laboratory activity (or requirement for demonstration) so that students obtain quick results and able to see the software design works successfully without excessive effort or disappointment	Cubero, 2015

The PBL approach, however, provides more spaces for the development of skills and understanding of concepts and experimental processes. The PBL model can also change the concept of conventional learning by emphasizing the concept of self-learning (Iturbe & Pelayo, 2010). The PBL approach starts with problems as a framework (Lambros, 2004), and high motivation to determine their own learning (Debnath, 2011). In other words, students are responsible for their self-learning and also independently determine learning content according to the predetermined objectives. Therefore, the PBL method is different from the traditional method. The PBL has proven to be very effective in engineering education, but there is still room for improvement (Mayer, 2013). Hence, the importance of PBL in engineering such as Industrial Microcontroller is seen to enhance students' confidence in problem solving skills, as well as their self-learning as an advantage in the areas before pursuing their future career. Figure 1 shows the comparison between conventional learning approach with PBL approach (Kou & Mehta, 2005; Debnath, 2011).

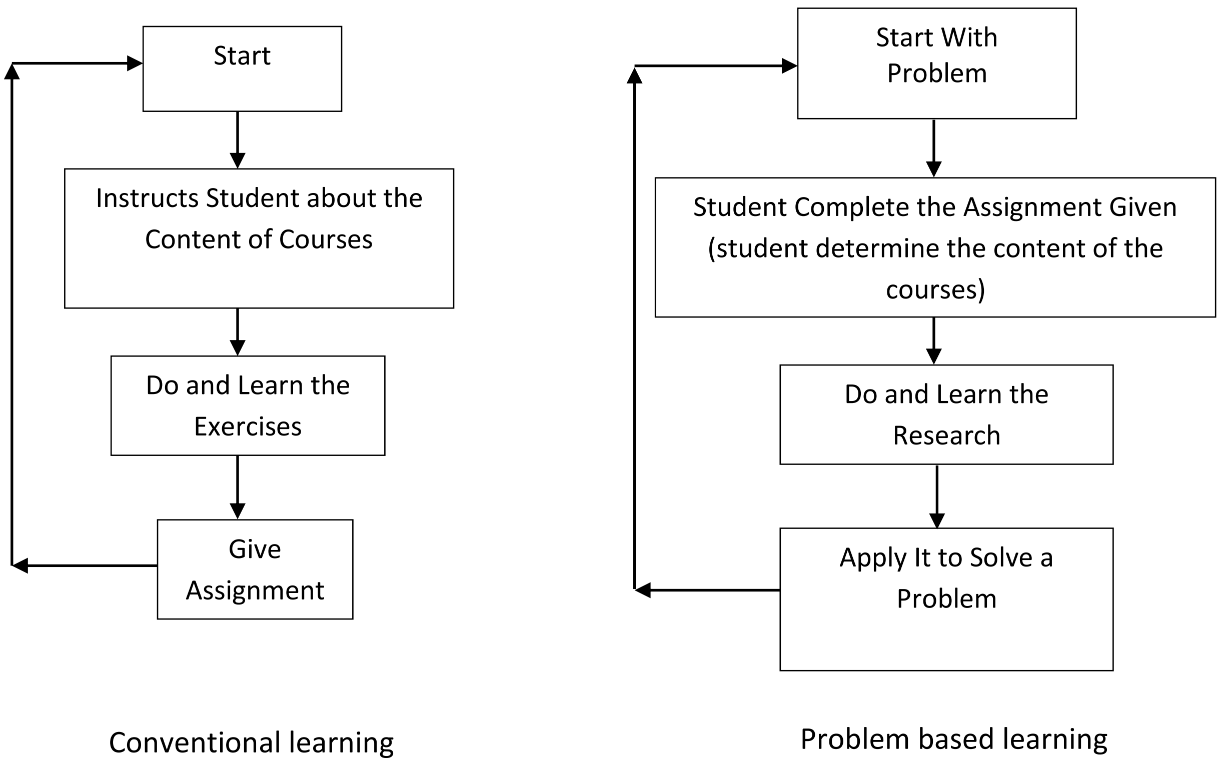

Figure 1. Conventional approach against PBL approach (*Kou & Mehta, 2005; Debnath, 2011*)

PBL Process in an Engineering Course

The PBL process in the classroom begins with the problem that will guide the students in the learning session and will be aligned with six stages in the Bloom's Cognitive Taxonomy (Bloom, Engelhart, Hill, Furst & Krathwohl, 1956; Anderson & Krathwohl, 2001; Striegel & Rover, 2002):

- Knowledge – existing knowledge about something particular
- Comprehension – meaningful objective, behavior, answer and action
- Application – solve problems using information obtained in new or different situations
- Analysis – examine the information in depth and draw conclusions
- Synthesis – applying main knowledge creatively
- Assessment – evaluate information and idea

Figure 2 shows the PBL features or steps that have been summarized in three stages (Tse & Chan, 2003) namely:

Stage 1: Identified and Define Problems

The first stage is that students need to deal with new problems related to real-world scenarios. The basic questions that need to be inquired are as follows:

- What should I need to know about these problems and questions?
- What do I need to know in order to handle this problem or question effectively?
- What resources do I need to solve this solution or hypothesis?
- At this point, students need to focus on problem statement, although the information obtained is something new, students need to make some changes so that the problem is easier to be accessed and understood.

Stage 2: Access, Evaluate and Apply Information Obtained

The second stage is that after students have identified the problem, they need to use the resources available to access, evaluate and use the information to solve the problem. Student may access print, human or electronic information resource to gather knowledge.

Stage 3: Synthesis and Evaluation

The third stage is that students need to synthesize and demonstrate their achievements through presentations to show their work regularly. At the end of the lesson, students gain new knowledge and apply them in new situations.

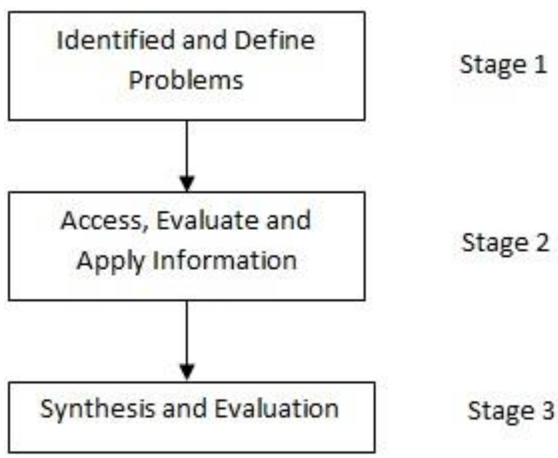

Figure 2. PBL features or steps that have been summarized in three stages *(Tse & Chan, 2003)*

Conclusion

Based on literature review, PBL is an effective method of learning in engineering and technical fields which emphasizes learning features based on real-world situations. Students have the opportunity to train themselves to learn self-learning techniques which are important elements for their future career. In addition, students can improve their learning outcomes through teamwork and build confidence through activities conducted in the classroom. The PBL method can produce more motivated learners, build a deeper understanding of the real world, encourage self-learning, improve critical thinking, build cognitive skills, improve problem solving skills, teamwork and communication skills. In conclusion, PBL is a learning method that can nurture students' interest in learning engineering in a more interesting and effective way.

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