THE EFFECTS OF PROBLEM BASED LEARNING ON KNOWLEDGE ACQUISITION, CRITICAL THINKING, AND INTRINSIC MOTIVATION OF ELECTRICAL ENGINEERING STUDENTS

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ABSTRACT

It is timely with the agenda of polytechnic educational transformation, this research was initiated to examine the effects of Problem Based Learning (PBL) on students' knowledge acquisitions, critical thinking ability, and intrinsic motivation and thus to propose a PBL instructional procedure, for the polytechnic's electrical engineering course. An experiment, consisting of pre-test and post-test, was carried out on 53 undergraduate students of electrical engineering course, who attended the Electrical Technology Module (ET101) in their first semester. A control group was maintained in order to verify the results of the experiment. The treatment used a special design of PBL procedures in the experimental group for a ten weeks period, and the existing method of conventional teaching was retained in the control group. Participants completed pre-test and post-tests based on three instruments: knowledge acquisition test, translated version of The Cornell Critical Thinking Test Specimen set, and intrinsic motivation questionnaire. The data were analysed using MANCOVA and results were obtained. Students' knowledge acquisition in the PBL group was significantly higher than that of their counterparts [F (1, 44) = 5.37, $p < 0.05$], with medium effect size (d = .68). Students' intrinsic motivation in the PBL group was significantly higher than that of their counterparts, [F (1, 44) = 5.18, $p < 0.05$], with medium effect size (d = .68). However, students' critical thinking ability in the PBL group was not significantly different from that of their counterparts in the TLA group [F (1, 44) = .019, $p > 0.05$]. Therefore, it can be concluded that PBL enhances students' knowledge acquisitions and intrinsic motivation, but does not improve students' critical thinking ability as compared to conventional approach. The implication is that the PBL procedures used in this study may be useful for educators in polytechnics, though some modifications are required to fine-tune the original framework for future implementation.

ABSTRAK

Sejajar dengan agenda transformasi pendidikan politeknik, satu kajian telah dilaksanakan bagi menguji keberkesanan kaedah PBM terhadap perolehan pengetahuan, pemikiran kritis, dan motivasi intrinsik pelajar dan sekaligus mencadangkan model kaedah PBM. Satu eksperimentasi beserta ujian sebelum dan selepas telah dilaksanakan terhadap 53 orang pelajar semester pertama dalam kursus kejuruteraan elektrik yang mengambil modul Teknologi Elektrik (ET101). Kajian ini melibatkan sebuah kumpulan kawalan sebagai perbandingan kesahihan dapatan. Kaedah pengajaran PBM telah dilaksanakan kepada kumpulan rawatan selama 10 minggu, manakala kaedah pengajaran yang sedia ada (tradisional) dikekalkan bagi kumpulan kawalan. Para pelajar telah melengkapkan tiga jenis instrumen (ujian sebelum dan selepas) iaitu: Ujian perolehan pengetahuan, set versi terjemahan bagi *The Cornell Critical Thinking Test Specimen Set*, dan soalselidik motivasi intrinsik. Data yang diperolehi dianalisa dengan menggunakan kaedah MANCOVA dan keputusannya diterjemahkan. Didapati, perolehan pengetahuan pelajar dalam kumpulan PBM lebih tinggi berbanding kumpulan kawalan [F (1, 44) = 5.37, $p < 0.05$], dengan *effect size* (d = .68) sederhana. Motivasi intrinsik pelajar juga lebih tinggi berbanding kumpulan kawalan [F (1, 44) = 5.18, $p < 0.05$], dengan *effect size* (d = .68) sederhana. Walaubagaimanapun, pemikiran kritis pelajar bagi kumpulan PBM tidak berbeza berbanding kumpulan kawalan [F (1, 44) = .019, $p > 0.05$]. Oleh itu, dapat disimpulkan bahawa PBM meningkatkan perolehan pengetahuan dan motivasi intrinsik pelajar, akan tetapi tidak meningkatkan pemikiran kritis mereka berbanding kaedah pengajaran secara tradisional. Implikasinya, kaedah pengajaran PBM yang digunakan dalam kajian ini boleh dimenfaatkan oleh tenaga pengajar di politeknik melalui pengubahsuaian terhadap rangkakerja asal untuk pelaksanaan masa hadapan.

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LIST OF SYMBOLS AND ABBREVIATIONS

3C3R	-	Model of PBL problem design by Hung (2006)
A-B-A-B	-	An experimental research design
CCTTS	-	The Cornell Critical Thinking Test Specimen
CTE	-	Career and Technical Education
DPCCE	-	Department of Polytechnic and College Community Education
DPE	-	Department of Polytechnic Education
EED	-	Electrical Engineering Department
MoE	-	Ministry of Education
MoHE	-	Ministry of Higher Education
MoHR	-	Ministry of Human Resource
PBL	-	Problem based learning
POPBL	-	Project Oriented Problem Based Learning
SCL	-	Student centred learning
SDT	-	Self Determination Theory
SPM	-	Sijil Pelajaran Malaysia
TCL	-	Teacher centred learning
TLA	-	Traditional learning approach
TVE	-	Technical and vocational
US	-	United States
VET	-	Vocational Education and Training

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Technical and Vocational Education (TVE) in Malaysia, is similar to every other part of the education sector in the country, in that it is undergoing large scale reformation. Over the past 20 years, TVE has been a visible part of the government's primary concern (Department of Polytechnic and Community College Education - DPCCE, 2009). Many development plans and changes to education have concentrated on the TVE sector. This can be observed through the initiative to increase the number of TVE institutions, such as polytechnics, through a series of national budget allocations (Ministry of Finance, 2003; Ministry of Finance, 2008; DPCCE, 2009; DPE, 2011). The main motivation for this initiative is the provision of more skills training opportunities for school leavers, in order for them to become qualified technical assistants, technicians, technologists, semi-professionals, and business personnel (Mustafa, 2001).

During the recent global competition for job placements, skill training has been identified to be essential to determine graduates' survival (Wang, 2008). Without specific skill training, doubt exists that graduates especially from engineering field may be incapable of solving tasks and applying their knowledge in an actual workplace environment. Particularly, in this new technology era, the workplace contains more complicated and sophisticated high-tech machinery and computerized systems, which create more complex and ill-structured problems (Tan, Teo and Chye, 2009). In this capacity and challenges, hands-on skills alone would not be sufficient to deal with the complexity of problems in an actual workplace environment (Bakar and Hanafi, 2007).

There is a need for engineering graduates that are capable of solving problems, with multiple skills, that are innovative, creative, as well as having good social skills and personal values.

In response to these demands, polytechnic institutes have introduced several steps to improve their teaching and learning system through the polytechnic transformation agenda (Department of Polytechnic Education - DPE, 2009a; DPE, 2010). The existing system uses a Traditional Learning Approach (TLA) within a Teacher Centred Learning (TCL) boundary, which is seen as less relevant in the 21st century; particularly in producing such desired graduates. However, the recent campaign seeks to shed light on the move to a new delivery system approach in polytechnics. Student Centred Learning (SCL) was introduced to replace the TLA through several learning methods and strategies. These include the method such as Problem Based Learning (PBL), case-study, practical activities, laboratory work, collaborative learning, computer-assisted learning, and group discussion (DPCCE, 2008). However, an observation reveals that there is much room for improvement for the current SCL implementation. The SCL implementation according to these specific approaches should be referring to specific model guidance. In addition, the proposed SCL approach, in the polytechnic's teaching and learning system should be more authentic or closer to the world of work (Jonassen, Strobel and Lee, 2006).

The move to a new learning approach, such as PBL, is seen as a possible way out of this issue. PBL has been widely discussed as an effective learning approach that promotes students' knowledge acquisition and skills (Dochy et al., 2003); especially in the medical field (Savin-Baden, 2000; Strobel and Van Barneveld, 2009). In fact, the PBL approach has been widely used in educational institutions worldwide including Denmark, Canada, Australia, and recently, Singapore (Wang, Fong and Alwis, 2005; Kolmos et al., 2007; Brodie and Gibbings, 2007). In addition, PBL has spread to diverse disciplines, from schools to higher education levels, including chemical engineering (Zhang, 2002), electronic engineering (Mantri et al., 2009), electrical engineering (Helerea et al., 2008), engineering and surveying (Brodie and Gibbings, 2007), science education (Wong and Day, 2009), mathematics (Kwon, Park and Park, 2006), business and entrepreneurs (Mossuto, 2009), and agriculture (Burris, 2005; Anderson, 2007).

PBL is a motivating, challenging, and enjoyable learning approach (Norman and Schmidt, 2000) that has resulted from the process of working towards understanding or resolving a problem (Barrows and Tamblyn, 1980). PBL pedagogy, promotes learning through the concept of 'learning by doing', which creates an opportunity for students to learn by experiencing the process of problem solving (Woods, 2000). In PBL, the teacher acts as a facilitator and responsible to monitor students' progress and stimulate their meta-cognition (Wee, 2004). The facilitator encourages students to think creatively and critically in looking for a best solution to a complex and ill-structured problem (Hmelo-Silver, 2004). In this capacity, the overall process of problem solving is actually simulating professional practices (Barrows and Tamblyn, 1980; Wee, 2004). Additionally, PBL involves students in the learning community, through cooperative learning with group members, as well as promoting collaborative learning with other experts (Brodie and Borch, 2004).

Recent research has highlighted PBL effectiveness on targeted learning domains, such as knowledge acquisition (Dehkordi and Heydarnejad, 2008; Bilgin, Senocak and Sozbilir, 2009), critical thinking ability (Sendag and Odabas, 2009), and motivation (Martin, West and Bill, 2008). On the other hand, other research has produced discouraging findings on these particular domains (Chang, 2001; Choi, 2004). Although students enjoy PBL, the relationship of each of these variables presents equivocal findings. Some findings illustrate that students with better knowledge acquisition had a good ability in thinking critically (Tiwari et al., 2006; Deal and Pittman, 2009), but some agree that both variables were independent (Burris, 2005; Anderson, 2007).

Despite these equivocal evidences, PBL inclusion in higher education is continually being accepted in preparing for competent graduates; particularly in the engineering education field (Jonassen et al., 2006). Adapting PBL into an institutional curriculum, specifically into teaching and learning in the classroom, presents a complex task. It must be based on specific purposes, intended learning outcomes, and aligned with the institution's mission and vision (Savin-Baden, 2000; Moesby, 2005). In line with the polytechnic's campaign, as well as the knowledge gap exist in the existing literature; this study was initiated to evaluate the effectiveness of PBL model, in an engineering education context in polytechnics. The central of research focus was to investigate the effects of PBL on several variables, according to the philosophy and learning outcomes of PBL, when being used as a main instructional method in the classroom.

1.2 Background of the study

Applying a similar concept in education, evaluating PBL must be based on PBL intended learning outcomes. The PBL intended learning outcomes include deep-content learning, problem solving ability, self-directed learning, and collaborative learning (Hmelo-Silver, 2004; Belland, French and Etmer, 2009). In this study, deep-content learning refers to the first variable i.e., students' knowledge acquisition. The second variable is the approach to problem solving i.e., critical thinking. The third variable is intrinsic motivation, which typically becomes a major reason for PBL implementation (Hmelo-Silver, 2004).

These variables are some of the most important aspect in learning. Knowledge acquisition that is specific to concepts, principles, and procedures could enhance students' better understanding, as well as improve knowledge retention (Gijbels et al., 2005). Critical thinking falls within the family of higher cognitive abilities (Facione, 1990; Sendaq and Odabas, 2009), which produce effective thinking and problem solving (Bailin, 1987; Treffinger, Isaksen and Dorval, 2006). While, intrinsic motivation is an important aspect of a pre-condition to learning (Fink, 1999; Turner and Baskerville, 2011), and determines the students' persistence in learning (Ryan, 1982; Vansteenkiste et al., 2004). For these reasons, these variables were typically included in evaluating PBL effectiveness in most of PBL research.

Knowledge acquisition is one of the common variables of interest in evaluating PBL effectiveness that can be measured in a specific manner. According to Sugrue (1995), assessing knowledge can be specific according to concepts, principles, and procedures. In this capacity, previous study findings indicated that the PBL approach was effective in constructing students' knowledge acquisition, in the aspect of concepts and principles (Capon and Kuhn, 2004; Bilgin et al., 2009). Meanwhile, evidence also indicated that the PBL and TLA contribute equally well on students' concepts and principle knowledge acquisition (Dehkordi and Heydarnejad, 2008; Sendaq and Odabas, 2009).

In a wider educational context, the studies that reported PBL as being less effective (Chang, 2001; Matthews, 2004; Anderson, 2007) were quite balanced with the studies that reported a more effective construction of students' knowledge acquisition of procedures or applications (Capon and Kuhn, 2004; Kasai, Sugimoto and Uchiyama, 2006; Dehkordi and Heydarnejad, 2008). When compared to Bloom's taxonomy of the cognitive domain, PBL appears to be effective in promoting students' learning at a higher cognitive level of application and evaluation, but not at the understanding level (Alcazar and Fitzgerald, 2005; Dehkordi and Heydarnejad, 2008).

A systematic review in the medical field concluded that students using the PBL approach gained slightly less factual knowledge of concepts and principles (Dochy et al., 2003). In addition, there was no convincing evidence to support that the PBL instructional approach improved students' knowledge and clinical performance (Colliver, 2000). This conclusion is consistent with the reason why PBL students were inclined to score lower in their final examinations (Cheng et al., 2003). Given knowledge, as a whole structure of concepts, principles, and procedures; the systematic evidence on the effectiveness of PBL appears to be equivocal, according to these structures (Gijbel et al., 2005). Therefore, this inconclusive finding calls for more studies that scrutinize the link between PBL and knowledge acquisition - specifically, in concepts, principles, and procedures or applications.

In relating PBL to higher order thinking skill components, several studies that are related PBL and critical thinking have resulted in positive findings (Derry et al., 2000; Tiwari et al., 2006; Iwaoka, Li and Rhee, 2010). However, several studies also resulted negative findings, or no significant difference of the two comparison groups, in investigating the effects of PBL on critical thinking (Polanco, Calderon and Delgado, 2004; Choi, 2004; Sulaiman, 2011). In addition, the studies on critical thinking were mostly done in the mathematical field (Leikin, 2009; Chiu, 2009). The studies that investigated the link between PBL and critical thinking across disciplines and populations were scarce (Tan, Chye and Teo, 2009).

In the aspect of affective domain, evidence suggests that PBL contributed to positive changes of students' intrinsic motivation (Pederson, 2003; Martin et al., 2008). Meanwhile, other research findings also indicate that PBL did not always positively stimulate students' intrinsic motivation (Anderson, 2007; Wijnia, Loyens and Derous, 2011). The effect of PBL on students' intrinsic motivation outside of medical education has been difficult to be explained (Artino, 2008). Therefore, a general conclusion is difficult generate, since few studies that link PBL and intrinsic motivation across educational disciplines and populations exist.

In summary, the research conducted on PBL and its effectiveness is timely. Since the polytechnic has launched a campaign to improve teaching and learning approaches, a model of SCL such as PBL is necessary. In addition, existing knowledge gaps concerning the link between PBL and knowledge acquisition, critical thinking ability, and intrinsic motivation have called for further research, particularly in the area of engineering education in polytechnics. The need for more research to be done in the above-mentioned areas has also been supported by previous researchers. It has been acknowledged there is room for more studies to be conducted in controlled experimental conditions, by using actual measures in assessing the effectiveness of PBL in cultivating students' knowledge acquisition, critical thinking ability, and intrinsic motivation (Tan, Chye and Teo, 2009). It is also important to determine whether PBL is capable of stimulating students' intrinsic motivation towards learning, and subsequently increasing students' knowledge acquisition and critical thinking ability.

1.3 Problem statement

In the recent polytechnic education transformation campaign, lecturers have been encouraged to implement SCL approach using methods such as PBL in order to improve the teaching and learning system in polytechnics. However, based on observations made on the current implementation of SCL in polytechnics, there is still plenty of room for improvement. The educational system has been bound by with the traditional form of education and assessment, which is seen as contradicting the spirit of SCL approach. Additionally, implementation of SCL using PBL approach in particular modules might be ineffective without specific instruction guidelines based on a specific PBL model. Therefore, the purpose of this study is to investigate the effects of PBL on students' knowledge acquisition, critical thinking ability, and intrinsic motivation. The next step is to propose PBL instructional procedures for the Electrical Technology (ET101) module of the Electrical Engineering course of the polytechnic.

1.4 Research objectives

The specific objectives of this study are:

(i) To investigate the effect of PBL on students' knowledge acquisition.
(ii) To determine the effect of PBL on students' critical thinking ability.
(iii) To examine the effect of PBL on students' intrinsic motivation.
(iv) To compare the effect of PBL on knowledge acquisition between students with a technical and non-technical background.
(v) To compare the effect between PBL and TLA on knowledge acquisition amongst students with a non-technical background.
(vi) To propose a model of PBL for the polytechnic's electrical engineering course, specific into Electrical Technology (ET101) module.

1.5 Research questions

(i) What are the effects of PBL on knowledge acquisition of electrical engineering students?

(ii) What are the effects of PBL on critical thinking ability of electrical engineering students?

(iii) What are the effects of PBL on intrinsic motivation of electrical engineering students?

(iv) What are the effects of PBL on knowledge acquisition of students between technical and non-technical background?

(v) What are the effects between TLA (control group) and PBL (experimental group) on knowledge acquisition of students with a non-technical background?

1.6 Hypotheses

(a) There is no statistically significant difference in mean score of the knowledge acquisition test between the control and experimental group.

(b) There is no statistically significant difference in mean score of the critical thinking test between the control and experimental group.

(c) There is no statistically significant difference in mean score of the intrinsic motivation questionnaire between the control and experimental group.

(d) There is no statistically significant difference in mean score of the knowledge acquisition test between students with technical and non-technical background in the experimental group.

(e) There is no statistically significant difference in mean score of the knowledge acquisition test between the control and experimental group amongst students with non-technical background.

1.7 Theoretical framework

In a PBL context, specific learning activities are often related to Constructivist Learning Theory. This is true; since the proposed instructional principles in this theory represent the most relevant explanation that relates PBL to educational theory. This was clearly explained in several recent publications (Camp, 1996; Savery and Duffy, 2001; Hmelo-Silver, 2004; Kolmos et al., 2007; Hmelo-Silver, Duncan and Chinn, 2007). The relationship between this theory and variables are summarized in Figure 1.1 below:

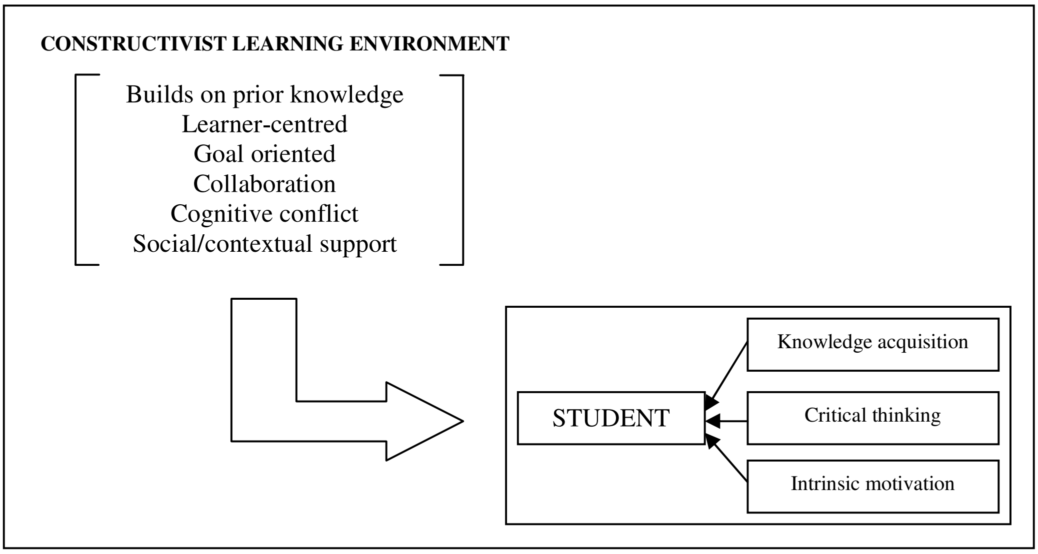

Figure 1.1: Theoretical Research Framework
(Savery and Duffy, 2006; Hmelo-Silver et al., 2007; Hmelo-Silver and Eberbach, 2012)

Based on Figure 1.1, PBL instruction is consistent with the Constructivist Learning Theory, for three primary principles (Savery and Duffy, 2001): Firstly, learning takes place through a holistic process of interaction with the environment. Secondly, learning is stimulated by cognitive conflict, and thirdly, learning involves social interaction. Knowledge is not absolute, but is constructed through the interpretation of previous experience of an existing knowledge structure (Schmidt, 1994; Savery and Duffy, 2001; Hmelo-Silver and Eberbach, 2012).

In the PBL approach, students solve an actual-world problem (or simulation) in a physical work space. They learn concepts and principles through the process of problem solving, based on specific learning goals (Palincsar, 1998; Savery and Duffy, 2001). Students integrate the new concepts and principles learned, into existing knowledge structures, by making an interpretation based on their previous knowledge and experiences (Schmidt, 1994; Savery and Duffy, 2001).

In this context, the authenticity of an actual-world problem promotes the students' ability to apply and relate these concepts and principles (Savery and Duffy, 2001). Interaction with the environment helps them to translate the concepts and principles learned, into new work practices (Garvin, 1993). Subsequently, these concepts and principles are converted into procedural knowledge when they reach a certain level of higher performance (Winterton et al., 2005).

Students construct higher order thinking skills, especially critical thinking ability, through PBL activities (Savery and Duffy, 2001; Hmelo-Silver, 2004). The authentic and ill-structured problem that is posted creates a cognitive conflict, which promotes students' thinking ability (Wee, 2004; Semerci, 2006). This typically occurs during a group brainstorming session, as solving a problem requires students to critically consider one possible best solution for the problem (O'Grady and Alwis, 2002; Wee, 2004). Students interact with each other, argue, reason, and debate, and this contributes to the development of reasoning or critical thinking ability (Palincsar, 1998; Savery and Duffy, 2001). In this context, their interaction with a facilitator (or peers) serves as stimuli during the problem solving process (Palincsar, 1998: Wee, 2004). According to Wee (2004), probing questions function to engage students in a systematic cognitive process that enriches students' ability to reason.

Students are also motivated to learn in the PBL approach. According to Schunk (2004), motivation is relevant to constructivism, based on contextual factors and teachers' expectation. From these contextual factors, students participate in a variety of learning activities within a diversity of members in a group. Students also have autonomy, self-control, and are free to make decisions on their learning (Hmelo-Silver, 2004). Students' work in a small group, interacts, and helps each other. Therefore, learning becomes more interesting and students enjoy participating, as well as intrinsically motivated (Ryan and Deci, 2000). Students also feel challenged to achieve teacher's expectation (Schunk (2004). Several authors agreed that these elements effectively motivate students in the learning process (Albanese, 2000; Pederson, 2003).

In summary, careful analysis indicates that any specific learning activity within PBL is supported by theory. The development of knowledge acquisition, critical thinking ability, and intrinsic motivation in a PBL environment is therefore theoretically grounded. In this sense, the Constructivist Learning Theory appears to be the main philosophy of the specific PBL process.

1.8 Significance of the study

(i) This research contributes to knowledge, where the findings provide more scientific evidences on the effect of PBL on students' learning domains; particularly on knowledge acquisition, critical thinking ability, and intrinsic motivation.

(ii) This study's findings will shed light on the potential of PBL in contributing to students with better understanding and increase motivation.

(iii) This study is significance for lecturers in polytechnic, in order to provide sources of reference and guidance in implementing PBL, as well as helps to enrich existing pedagogical skills.

(iv) In line with a departmental motivation to increase the quality of teaching and learning (DPCCE, 2008), this study's findings provide another sources of evidence for the Research and Development (R&D) team, in the Department of Polytechnic Education. This is specifically aimed at the curriculum development division, which requires more research findings, in order to develop an effective curriculum that is grounded by a SCL approach.

(v) This study finding also important for a polytechnic's top-management level in identifying the necessity for a full scale PBL implementation; similar to other successful international polytechnics (Wee, 2004; Wang et al., 2005; Lahtinen, 2005). This study provides information whether PBL is suitable, feasible, and workable, in respect to polytechnic's context, sample, and population.

1.9 Scope of the research

(i) This study examined the effects of PBL within the scope of knowledge acquisition, which is specific into concepts, principles, and procedures. This study also includes critical thinking and intrinsic motivation as parts of measuring PBL effectiveness.

(ii) This study involved two groups of first semester students enrol in the Electrical Technology (ET101) module in polytechnic.

(iii) The material used for instruction in both group was the two units of the ET101 module.

1.10 Limitations of the research

(i) This study limited to 10 weeks of treatment that appropriate for the experimental study.

(ii) This study measured general (multi-aspect) critical thinking as according to standard instrument used (the CCTTS).

(iii) The instrument used to measured knowledge acquisition was within the boundary of the selected parts of concepts, principles, and procedures content within unit 2 and 3 of ET101.

(iv) This study measured intrinsic motivation based on the aspects defined that was according to the Intrinsic Motivation Inventory.

(v) The sample was limited to students of selected groups. Cost and time prohibited the study of a larger sample.

1.11 Assumptions

The instruments i.e., Multiple Choice Questions (MCQ), Cornell Critical Thinking Test Specimen (CCTTS), and an intrinsic motivation questionnaire, were assumed to be valid and reliable in measuring the respective variables i.e., knowledge acquisition, critical thinking ability, and intrinsic motivation. Students responded honestly to the knowledge acquisition test, critical thinking test, and questionnaire items.

1.12 Definition of terms

Knowledge acquisition

Knowledge acquisition refers to information attainment, such as concepts, principles, and procedures (Sugrue, 1995), when two instructional methods are used. For this study, knowledge acquisition was operationally defined as the gain-score of a knowledge acquisition test, administered both before and after treatment.

Concepts

According to Sugrue (1995), knowledge of concepts is an understanding of individual knowledge, such as subjects, events, peoples, symbols, or ideas that share common attributes and are identified by the same name. The examples of concepts are electricity, voltage, current, and resistance. The acquisition of these concepts refers to students' ability to know or recognize, understand, and apply, according to the first three levels of Bloom's taxonomy.

Principles

Knowledge of principles is the understanding of the relationship between concepts, such as rules, laws, formulas, or statements that are characterized by the relationship between two concepts (Sugrue, 1995). The acquisition of principles refers to students' ability to relate several concepts. For example, the relationship between current and resistance, when the resistance in a particular circuit increases, the current passing through will decrease accordingly. An understanding of this relationship was measured according to the first three levels of Bloom's taxonomy.

Procedures

The knowledge of procedures is the application of the concepts and principles that link each other to a condition or procedure (Sugrue, 1995). According to Winterton et al. (2005) concepts and principles are known as declarative knowledge; which is "know-that". Meanwhile, the knowledge of procedures is known as "know-why" or "know-how". The knowledge acquisition of procedures refers to students' ability to know, understand, and apply procedures. For example, Kirchhoff's law is performed during circuit analysis, according to particular procedures or particular condition of a circuit. Understanding of these procedures was measured according to the first three levels of Bloom's taxonomy.

Critical thinking ability

Critical thinking is the ability to justify and reflect an individual's believe of their decision. This, in agreement with Ennis et al., (2005) means that critical thinking, as reasonable and reflective thinking, focuses on deciding what to believe or do. Believing in a decision depends on several inferences, such as induction, deduction, and value judgement, as well as the bases of such inferences, which include the results of other inferences, observations, statements made by others, and assumptions (Ennis, 1984). For this study, critical thinking ability changes were operationally defined as the composite score of the Cornell Critical Thinking Test Specimen (CCTTS); administered both before and after treatment.

Intrinsic motivation

Intrinsic motivation refers to an individual pleasure or value, associated with the activity itself (Staw, 1989). Some authors define intrinsic motivation as a life-force or energy, or the pleasure and satisfaction of doing an activity for itself that is derived from participation (Ryan and Deci, 2000). For this study, students' intrinsic motivation changes were operationally defined as the composite score of items intrinsic motivation questionnaire, administered both before and after treatment.

Instructional procedure

Instructional procedure refers to the method used in teaching unit 3 and 4 of ET101 module in both experimental and control groups.

Experimental group

Experimental group refers to a set of subjects, randomly selected and assigned as a group that were treated with the PBL method.

Control group

Control group refers to a set of subjects, randomly selected and assigned as a group that were treated with the TLA.

1.13 Thesis outlines

This thesis is organized into five chapters. Chapter 1 describes the background of the study. It also includes the objectives, hypotheses, and theoretical framework of the study. Chapter 2 builds a strong fundamental basis for the whole idea of the study. It describes the relevant body of knowledge within the PBL niche area. The discussion focuses on the current circumstances in research that relates to PBL with the variables being studied. Chapter 3 describes the research design and procedures. Chapter 4 reveals the major results of hypotheses testing. Finally, Chapter 5 summarizes and discusses the findings of the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction to chapter

This chapter describes several broad scopes of relevant body of knowledge, when PBL is used as an instructional method in this study. Over 200 scientific sources from 1963 to 2011 were referred including a large number of supported materials, in order to build a good understanding in the area of interest. Based on these materials, the researcher summarized the content into five main sections. The body of the literature review is shown in Figure 2.1:

(i) Technical and Vocational Education (TVE)
(ii) An introduction to PBL
(iii) The PBL models
(iv) The PBL research
(v) Measuring variables

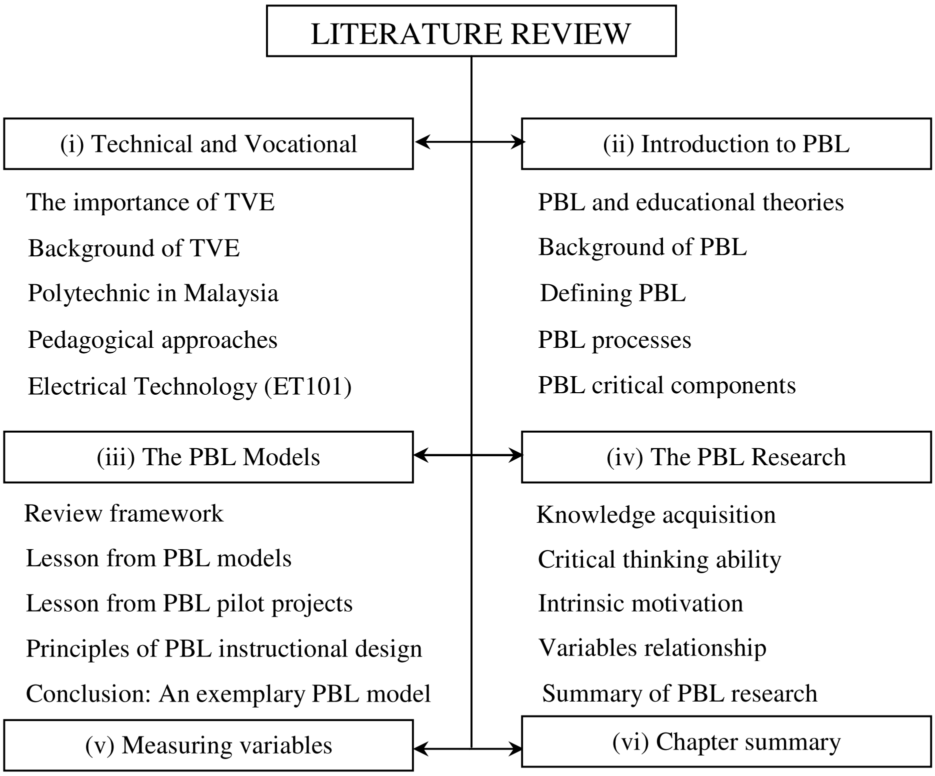

Figure 2.1**:** The body of the literature review

2.2 Technical and Vocational Education (TVE)

Lately, educational transformation has become one of the main agendas by governments in many countries. Many education fields have been affected, including the Technical and Vocational Education (TVE). This is in response to the demands for skilled workers as well as the aspirations of governments to attain the status of high-productivity and high income countries, which are driven by modern industrial economy. Finland is a good example; the government is concerned to provide equal accessibility to education and training for the entire population (Kyro, 2006). For that reason, the Finnish government had allocated large amount of funds to increase the quality and attractiveness of TVE programmes. Similarly, in Australia, the government had invested much money to form a unified Vocational Education and Training (VET) system, implemented in school and right up to institutions of higher learning (Reese, 2009).

The United States (US) is another example; the government had focused on the Career and Technical Education (CTE) since in the past war era to seek the dignity of labour, generate power, and contribute to the harmony of development (O' Lawrence, 2008). As a result, a specialist from the US can be employed in any place in the world today. In fact, the US has been exporting CTE goods and services to many other nations (Fretwell, 2009). According to O' Lawrence (2008), the US example has influenced the establishments of vocational education system in many countries. The key to success of CTE in the US can be attributed to several factors, which include the government commitment in investment, educational transformation, and the policy of integration between core academic and vocational education (O' Lawrence, 2008).

Malaysia seems to learn from the experience of the few countries mentioned. The government is committed to improve the TVE field through a series of annual allocation in national budgets. A large portion of funds has been allocated to reform the national TVE programmes. For example in 2003, a total of RM408 million was invested to build more community colleges, as an addition to the existing 17 community colleges (Ministry of Finance, 2003). In order to promote students' enrolments to TVE sector, a total of RM190 million was invested, which was funded through an allocation of the national budget in 2005 (Ministry of Finance, 2005). Further in 2008, the government allocated RM2 billion to upgrade the existing polytechnics and community colleges nationwide, including other TVE providers managed by the government (Ministry of Finance, 2008).

Additionally, as a part of government's initiatives and continual efforts to improve the TVE field, the Minister of Higher Education (MoHE) has recently introduced a new "re-branding" strategy to stimulate the local TVE sectors. Three polytechnics were upgraded to premier polytechnics, as an initial preparation for the establishment of the university polytechnic by 2015 (DPE, 2009a; MoHE, 2010). The university polytechnic will be functioning as a booster to the national TVE sectors, which provides more educational opportunities for youngsters at tertiary levels.

The re-branding initiative is consistent with the national vision of 2020, where more professional and semi-professional workers are needed in transforming the Malaysian traditional basis of economic. Seeing the potential of TVE in reforming the current economic tradition, the government continues in promoting technical skills training and strengthening the TVE for all sectors. The future climate of economic is expected to more activities that are intensively depending on knowledge, skills, and technology, as well as on the total factor of productivity (Bhandari, 2009). For that reason, the government has a concrete reason in upgrading the TVE sector to become more visible as a major field in educational mainstreams.

2.2.1 The importance of TVE

In the report of the Ministry of Human Resources (MoHR) in 2007, a total of 56,452 job seekers were amongst those with Sijil Pelajaran Malaysia (SPM) (MoHR, 2008). They were amongst the targeted cohort, who should be equipped with at least a professional certificate through a specific training. Training is more important, in the sense that workers need to be exposed and to be equipped with necessary skills for their job. Well trained workers will help to boost up the national productivity and thus their workplace involvement is highly valued by the industry.

It is within this context, TVE plays an important role as a platform for professional skills training for the youngsters. TVE includes a wide and variety of educational context of professional training that relates between the real world experiences and education system (Jacobs and Grubb, 2003; UNESCO-UNEVOC International Centre for Technical and Vocational Education and Training, 2006; Oketch, 2007). This definition reflects to a wider scope of interpretation, which is not only concerned on “hands-on” skills training, but also on the other competencies in educational context. These include an individual’s development on generic skills, such as communication skills and problem solving skills (Ciccolo, 2008).

All these skills are essential for graduates; it is particularly to survive in the global competitions of job placement (Wang, 2008). The high quality graduates are necessarily important in the new modern technology and information era. The merely hands-on skills would not be adequate in dealing with the complexity of the workplace problems (Bakar and Hanafi, 2007). There is a need for an individual with multiple skills, including creative ability, problem solving, critical thinking, social skills, and personal value. However, based on the current report from the statistic department (as for June 2011), 400,100 persons in the labour market has been unemployed (Principle Statistic of Labour Force, 2011). In this capacity, there is a doubt of a mismatch between TVE and the world of work, which needs to be improved for better (Bakar and Hanafi, 2007), in line with the growing demands from industrial sectors.

In dealing with the mismatch, the typical TVE curriculum provides an opportunity for students to have a workplace experiences (DPCCE, 2008). In this early exposures of industrial training, students are exposed to workplace environments and they are expected to develop their valuable generic skills (Velde and Cooper, 2000; UNESCO-UNEVOC International Centre for Technical and Vocational Education and Training, 2006). As such, students are more confidence when entering the new world of work. However, the industrial training contributes a very limited role on students' development of knowledge, skills, and attitude, due to a short period of this practice in many TVE institutions.

2.2.2 Background of TVE

TVE was first introduced as a formal education in Malaysia, since the inception of the "federal trade school" late in 1926, under the British education system (DPCCE, 2008). It was before TVE entering the formal education streamline, it was mostly known as a trade skills training for mechanics and fitters on the railways. Based on Leong (2008), the history of the trade skills training can be traced late in 1900's, when the government of Selangor engaged several local craftsmen comprising a wood-carver, a silversmith, a blacksmith, and tailor to teach their craft to Malay students. Soon after that, in other states, Perak has become the first state to establish the Malaysian Art School to provide such trade skills training.

In the British colonialism era, Malaya at that time was seeing the first establishment of trade school (Leong, 2008). Soon after the Second World War, the government of Malaya had concerned on the needs of technical training. As a result, the Federal Trade School was established in 1926 to provide a full time technical training for mechanics, fitters, machine workers, and other technicians. Since 1926, the TVE development had been undergoing many changes and challenges, and later in 1956 through educational committee report (Razak Reports), the establishment of technical institute had become the notion of the modern TVE in Malaysia. TVE became a major component in Malaysian educational settings, and continually grew through several educational policy recommendations through Rahman Talib Report in 1960, and the Cabinet Report in 1979 (Leong, 2008).

It was only in the past 20 years; TVE has become visible as a part of government's primary concern to produce the national skilled workforces. The government inspired more semi-professional and knowledge-workers (*k*-workers), in order to support the knowledge-economic (*k*-economic) mission for the impending vision 2020. As concerted efforts, several ministries and departments have involved in achieving this inspiration, which include the Ministry of Education (MoE), Ministry of Higher Education (MoHE), Ministry of Human Resources (MoHR), and Ministry of Youth and Sports (Leong, 2008).

Amongst these ministries, MoHE has been the major providers and hosts of several institutions and departments under TVE. The establishment of the Department of Polytechnic and Community College (DPCCE) in 2004 was the notion of the expansion of Malaysian TVE system (DPCCE, 2008). Then, the number of polytechnic and community college has been tremendously increased since in the past 10 years. In 1999, 13 polytechnics were established and the community college at that time was under proposal by the cabinet ministries. In the next 10 years, 27 polytechnics and 42 community colleges, as well as 21 community college branches have been in operations (DPCCE, 2008). The number of polytechnic and community colleges are expected to increase, in line with the continual revision of the national skills training and the policy for TVE.

The government of Malaysia is committed in improving the management and the delivery system. Recently in September 2009, the management of polytechnics and community colleges was divided into two departments (DPE, 2010). The Department of Polytechnic Education has become one of the entities along with the Department of Community College Education and the Department of Higher Education. The new structure of MoHE is depicted in Figure 2.2:

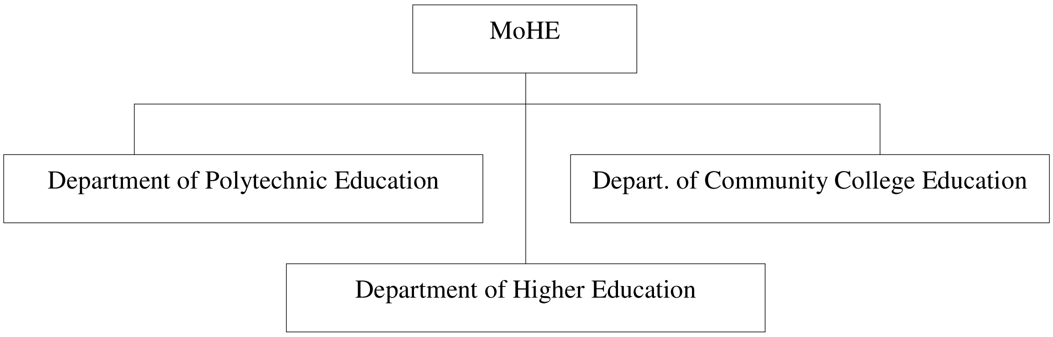

Figure 2.2: Organizational structure of the MoHE
(DPE, 2009a; DPE, 2010)

2.2.3 Polytechnics in Malaysia

The first polytechnic institute was formed in 1969, namely Ungku Omar Polytechnic in Ipoh, under the United Nation Development Plan (DPCCE, 2009). In conjunction with the growing interest on technical education, more polytechnics are needed as a feeder to the national workforce demands in 1970's. As a result, another polytechnic was established in 1976 in Kuantan and in 1985 in Kota Bahru, namely Sultan Haji Ahmad Shah Polytechnic and Kota Bharu Polytechnic respectively. Further, through the first National Industrial Development Plan 1985-1995 and the decision made by the Cabinet Committee on Training in 1991, more polytechnics were established nationwide (DPCCE, 2009).

Polytechnic institute has been dominating a large portion of technical education courses at diploma level. For that reason, the polytechnic institutions have become a chosen route in producing semi-professional technical workers, for students who are keen to acquire technical skills, yet unqualified to enrol in first-tier university engineering courses (Esa et al., 2009). Previously, the polytechnic establishment was to provide an opportunity for school leavers, in order to become qualified technical assistants, technicians, technologist, semi-professionals, and business personnel (Mustafa, 2001). However, in the recent polytechnic's transformation agenda, students who are keen to technical fields could go beyond the label of semi-professional workers.

The government's plan to establish university polytechnic by 2015 (DPE, 2009a; MoHE, 2010), has become a good indicator for the production of more professionals in this field. This initiative is a part of the plan to achieve the government's inspiration in producing more *k*-workers, as well as upholding the TVE sectors, in order to attract more students' participation.

The uniqueness of the polytechnic's curriculum has attracted a large portion of school leavers. Based on the quick facts report (March 2011), more than 89,000 students from various courses including engineering, technology, commerce, and services were accommodating 27 polytechnics nationwide (DPE, 2011). An intake for full time courses in January 2011 was 18,220. Within these, 28 engineering programmes are offered at diploma level in several field areas including electrical engineering, electronic, civil, mechanical, and mechatronic engineering (DPCCE, 2009). As for the year 2010, the list for 27 polytechnics, 28 engineering programmes, and the availability of the Electrical Engineering Department (EED) in polytechnic are illustrated in Table 2.1 and 2.2, which are enclosed respectively in the **APPENDIX A** and **B**.

Polytechnic's students' prospective; polytechnic institute intends to become the preferred institution for those seeking for tertiary educational opportunity (DPE, 2010). Students in polytechnic institute are from various background; some of them are already equipped with fundamental knowledge and basic technical skills from previous TVE secondary schools, while some others are freshmen from ordinary schools. According to minimum entry requirements, students who join the diploma engineering programme must pass five subjects including Mathematics, Bahasa Melayu and English Language in Sijil Pelajaran Malaysia (SPM) (DPCCE, 2009). This minimum requirement provides a wider opportunity for students to join polytechnic as an alternative pathway to higher education.

Polytechnic's Diploma Electrical Engineering programme; students enrol in the polytechnic's electrical engineering programme require six semesters in completing at least 93 credit hours, in a minimum period of three years (Curriculum Development and Evaluation Division, 2010). Students must complete several modules including core, general, specific, and elective modules. Each module ranges from one to three credit hours that is uniquely designed to combine both theoretical and practical knowledge.

Electrical Technology, Wiring Installation, Measurement, and Electronic Circuit Analysis, are the examples of the core modules in this programme.

2.2.4 Pedagogical approaches

In the recent educational transformation campaign, the polytechnic institute proposed SCL as an approach to improve the quality of teaching and learning methods (DPCCE, 2008). Polytechnic optimists with the SCL approach, the method can effectively builds students' specific skills, such as critical and scientific thinking, good knowledge management and confidence, writing skills, good interaction and presentation skills. In addition, the method such as SCL approach was clearly mentioned in the second thrust of the polytechnic's strategic planning for the year 2005-2010 (DPCCE, 2008).

In this context, several strategies have been implemented in supporting the implementation of SCL approach. These include the initiative to regularly monitor and assess the implementation of curriculum, as well as to enhance teaching and learning experiences for stakeholders (DPCCE, 2008). These have been performed using a new platform of an innovative pedagogical approach, through the methodologies such as PBL, case study, collaborative learning, and methods that promote multidisciplinary curriculum (DPCCE, 2008).

However, the current implementation of SCL approach reveals much room for improvement. Teaching and learning has been preoccupied with the traditional form of education and assessment that is seen as contradicting the spirit of SCL approach. Students spend much time in the classroom and passively take part in the learning session. They spend much time in the laboratory to perform practical activities merely according to the lab sheet instructions. Even though other forms of learning activities are sometimes taking place such as group project, computer-assisted learning, tutorial and group discussions, but students have a minimal role and space in making decision on their learning. In this context, teaching and learning is generally based on the teacher-centred learning. Additionally, SCL implementation using the method such as PBL in particular module, might ineffective without specific reference from a specific model (Masek and Yamin, 2009c; Masek and Yamin, 2009d; Masek and Yamin, 2010b).

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