

# Defining Vocational Education and Training for Tertiary Level Education: Where does Problem Based Learning Fit in? – A Literature Review

Ismail N.b<sup>a \*</sup>

*<sup>a</sup>Norhariati binti Ismail, Aston University, Birmingham and B4 7ET, United Kingdom*

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## Abstract

The purpose of this paper is to review the merit of Problem-Based Learning as a learning and teaching strategy for Vocational Education and Training institutions. The literature review presents a fresh perspective of Vocational Education and Training system and argues the effectiveness of its application in this 21<sup>st</sup> century education system. This article then compares a few active learning approaches such as Problem-Based Learning, Project-Based Learning and CDIO (Conceive-Design-Implement-Operate) which are commonly used in the engineering discipline. Then paper concludes with the findings and states the role of Problem-Based Learning in Vocational Education and Training context.

*Keywords:* Vocational education and training, problem base learning, active learning, tertiary level, engineering;

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## 1. Introduction

The learning and education approaches have developed significantly from traditional method or teacher centered learning. Teacher centered learning is content driven with educators focusing on course objectives (Ariffin et al., 2004). In teacher centered learning, educators normally will present, interact, discuss, demonstrate and communicate with students face to face (Azizan, 2010). As for engineering program, the approaches are mainly by lectures supplemented with tutorials (numerical problem solving) and practical (laboratory) classes. A similar approach is delivered for Vocational Education and Training where students normally start with describe, demonstrate, try-out by trainee and evaluate with feedback.

With the rapid change of technology and world globalization, it is essential to prepare students as they are the future workforce. The term ‘21<sup>st</sup> century Skills’ refers to skills that are required for employability (Dede, 2010). Thus, it is necessary to look back on our educational approach and pedagogy in order to accommodate the student to be an effective worker. An Active Learning approach which is centered around the student can encourage deep learning and also improve student’s competencies such as critical thinking, problem solving and creativity, communication skills as well as collaborative skills (Adams, Kaczmarczyk, Picton, & Demian, 2011; Nepal & Jenkins, 2011; Rojter).

The aim of this paper is to investigate the application of the Problem-Based Learning approach in Vocational Education and Training, particularly for tertiary level education. In addition to that, the discussion of this paper is only focusing on the engineering discipline. Starting with a background of Vocational Education and Training, this paper also reviews and compares other active learning approaches that are commonly used in the engineering discipline, which can also be used in Vocational Education and Training.

## 2. Background – Context: Vocational Education and Training and Active Learning

### 2.1. Vocational Education and Training

Vocational Education & Training is recognised globally as an effective learning method, which can contribute to economic growth (MacDonald, Nink, & Duggan, 2010). It is one of the terms in the education system that deals with practical hands-on experience, which is always related to the working environment. This education approach is different to the general academic education system, which builds analytical skills, theories and critical thinking whereas in vocational education, training is based on the job skills which are required in a specific area (Nilsson, 2010). Despite being label as ‘second class’ education compared to academic education system, the Vocational Education and Training policy that emphasizes on skills generates different perception on how it can benefit from the way the Vocational Education and Training is embedded in institutional context (Eyre, 2011). In addition to that, Eichhorst, Rodriguez Planas, Schmidl, and Zimmermann (2013) believed that “Vocational Education and Training gives an opportunity for young people who lack resources, skills or motivation to pursue their education to a higher level”(p. 1).

The acceptance and implementation of Vocational Education and Training varies throughout the world. In most countries, Vocational Education and Training is quite separate from the formal education system. Chappell (2003) indicates that the

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\* Corresponding Author name. Tel.: +44-121-204-3502  
E-mail address: ismailnb@aston.co.uk

reformation of the Vocational Education and Training system is due to the need for the education and training systems to be more aligned with the contemporary requirements of the economy (p. 22). MacDonald et al. (2010) added that “in Asia countries like Malaysia, Singapore and South Korea are focusing on ‘Human Resource and Workforce Development’ as the result of Vocational Education and Training where all entities, private, public and social contribute to the training and employment in the vocational education system” (p. 6). On the other hand, a country like Germany implements a dual system where higher education and Vocational Education and Training are structured together in order to embrace national qualification as well as the training requirements (Eichhorst et al., 2013). Regardless the implementation across nations, the primary advantage of vocational and technical education is to provide a skilled worker as per the market requirements. In context of the application to the engineering discipline, this will provide a skilful workforce that deals directly with industry and manufacturing sector.

Apart from that, United Nations Educational, Scientific and Cultural or UNESCO (2002) defines “Technical and Vocational Education as a comprehensive term referring to those aspects of the educational process involved, in addition to general education:

- the study of technologies and related sciences;
- the acquisition of practical skills, attitudes, understanding, knowledge relating to occupations in various sectors of economic and social life” (p. 7).

Though Vocational Education and Training manages to fulfil the aim of producing students with competencies in technical skill, Leung and McGrath (2010) stress that students lack employability skills. To support that, many studies had revealed that engineering graduates need more than technical knowledge in order to accommodate current employment requirements (Nair, Patil, & Mertova, 2009; Selvadurai, Choy, & Maros, 2012; Zaharim et al., 2010). In the current global working environment, additional skills are required in the areas of communication, collaboration and problem solving. The shortage of interpersonal skills amongst engineering graduates, particularly for Vocational Education and Training has given an alarming sign to improve the learning system (Leung & McGrath, 2010). Apparently, in Vocational Education and Training, the learning and teaching methods are normally delivered the traditional way, which is the ‘four steps method’, introduced by Allen (1919). This one way of learning has been used for a long time where students accept knowledge from the tutor without knowing the importance of why they doing it (Salleh, Othman, Esa, Sulaiman, & Othman, 2007).

Hence, the idea of ‘active learning’ has triggered the educators in order to replace this traditional method. An active learning approach is well accepted in the 21<sup>st</sup> century with many forms of active learning in place such as Problem-Based Learning, Project-Based Learning, CDIO, Inquire-Based Learning, and many more (Leung & McGrath, 2010; M. Prince, 2004; Michael Prince & Felder, 2007). All these new approaches have the same aim, which is to produce students with multiple competencies as well as to encourage lifelong learning. Despite many advantages, M. Prince (2004) revealed that some faculty are still sceptical in adopting active learning as their new teaching and learning approach. Therefore, it is crucial to understand each concept and approach in order to avoid misconception and fail to reach the aim.

## 2.2. *Active Learning*

### 2.2.1. *Definition of Active Learning*

Active learning is defined as instructional activities that require students in doing things and also think about what are they doing (Bonwell & Eison, 1991). This is different to traditional lecture methods, in which professors talk and students listen (Bonwell & Eison, 1991; M. Prince, 2004). Chickering, Gamson, and Poulsen (1987) added that in active learning, “students must do more than just listen” while M. Prince (2004) mentioned that active learning is a term normally used to relate “any suitable methods that engages student in the learning process” (p. 1). However, M. Prince (2004) also highlighted some confusion of Active Learning approaches in traditional taught engineering discipline since “it already ‘active’ through homework assignment and laboratories” (p. 1).

According to Felder and Brent (2009), students in active learning will respond to the question, problem or any type of challenge either as an individual or in a small group (p. 1). Besides, McConnell, Steer, and Ownes (2003) add that “active learning can foster growth of thinking skill and promote science literacy” (p. 205). As to date, there are few active learning approaches that have been used in application of engineering program which is believed also suitable for Vocational Education and Training approach. Common approach that has been using are Problem Based Learning, Project Based Learning, CDIO, Collaborative Learning, Inquiry-Based, Learning and etc (Leung & McGrath, 2010; M. Prince, 2004).

Whilst the application of active learning in engineering is widely reported (Catts, Falk, & Wallace, 2011; M. Prince, 2004; Michael Prince & Felder, 2007), the best suitable approach for Vocational Education and Training still remain unclear. Thus, the rationale for further discussion is to understand and compare each approach in order to select the most suitable method for Vocational Education and Training application. However, only three approaches are highlighted throughout the discussion namely Problem Based Learning, Project Based Learning and CDIO which are also commonly used in engineering program.

### 2.2.2. *Problem-Based Learning*

Problem-Based Learning is widely used nowadays. It is believed to be an effective and ideal teaching approach for the 21<sup>st</sup> century. Most researchers agree that Problem-Based Learning is a student-centered approach which focuses on real-life contexts in order to stimulate a series of skills such as critical thinking, research and collaboration during the learning process (Ariffin et al., 2004; Grigg & Lewis, 2013; Yusof et al., 2004). Problem-Based Learning was initially used by the Medical School of the McMaster University in Canada at the end of the 1960s (Akinoğlu & Tandoğan, 2007; De Graaf & Kolmos, 2003). It was then applied to other disciplines, including law, business studies, dentistry, economics, engineering and education (Akinoğlu & Tandoğan, 2007; Grigg & Lewis, 2013; Michael Prince & Felder, 2007).

In Problem-Based Learning, the primary goal of the approach is to enhance learning by requiring learners to solve problems (Hung, Jonassen, & Liu, 2008). Thus, the learning process starts when students are given an ill-structured and real world set of problem instead of direct lectures (M. Prince, 2004; Michael Prince & Felder, 2007). Ward and Lee (2002) pointed out that “by using the central concept of this approach, students will learn the content as effectively as through lecture by attempting to solve realistic problem” (p. 18). In this case, facilitators or instructors are required to develop the student’s intrinsic interest in the subject matter, by emphasizing learning as opposed to recall, promoting group work and helping students to become self-directed learners (Hmelo-Silver, 2004). As compared to the traditional method, the role of teacher / lecturer now changes as they need to facilitate the learning process rather than to provide knowledge to the student (Savery, 2006).

Apart from that, Savin-Baden (2000) defined Problem-Based Learning as “organizing the curricular content around problem scenarios rather than subjects or disciplines” (p. 2). He also added that this approach is “characterized by flexibility and diversity in the sense that it can be implemented in a variety of ways and across different subjects and disciplines in a diverse context” (p. 3). This statement is also agreed by de Graaff and Kolmos (2007) as “the solution of the problem can extend beyond traditional subject-related boundaries and methods” (p. 658). Thus, according to Savin-Baden (2000) “this ‘new’ diverse curricular helps students to ‘make sense’ for themselves where students have been enabled to understand their own situations and frameworks so that they are able to perceive how they learn, and how they see themselves as future professionals” (p. 2).

Another important element of the Problem-Based Learning approach is that the learning activity is handled by a small group of students rather than a big group (Barrows, 2006). Therefore, the aim of a small group session will encourage students to adopt deep learning and to be a self-directed active learner (de Graaff & Kolmos, 2007). This approach provides a learning environment which emphasizes on higher order thinking skills, multi-disciplinary learning, independent learning, teamwork and communication skills (Hmelo-Silver, 2004). Thus, Engel (1991) as cited by Ward and Lee (2002) mentioned that Problem-Based Learning has two distinct goals: to learn a required set of competencies or objectives and to develop problem solving skills that are necessary for lifelong learning (p. 18). Nevertheless, Savin-Baden (2000) added that students work in groups or teams to solve or manage these situations but they are not expected to acquire a predetermined series of ‘right answers’ (p. 3). A basic understanding of the Problem-Based Learning approach as compared to the traditional method is compared in Table 1.

Many studies report the effectiveness of the application of the Problem-Based Learning approach in the engineering discipline (Borgen & Hiebert, 2002; De Graaf & Kolmos, 2003; Northwood, Northwood, & Northwood, 2003; Yusof et al., 2004). The changes are made as most educators believe that this approach creates a viable alternative in producing a competent engineering graduate as compared to the traditional method. Various definitions, concepts and principles on the Problem-Based Learning approach have led to different applications among institutes and educators. De Graaf and Kolmos (2003) have compared a model used by the Dutch approach of directing the learning process through problem analysis and the Danish model of project-organised learning (p. 657). However, Borgen and Hiebert (2002) added that the implementation may vary and can be implemented at several levels according to the subject level, course level and institutional level (Borgen & Hiebert, 2002). While other educators struggling to find a suitable approach in Problem-Based Learning, Republic Polytechnic in Singapore introduced a unique approach titled ‘one day one problem’ which was integrated into the Problem-Based Learning curriculum (O’Grady & Alwis, 2002).

### 2.2.3. *Project-Based Learning*

Project-Based Learning is another innovative method that is believed to provide multiple strategies in the learning process in the 21<sup>st</sup> century (Bell, 2010; Ehrie; Musa, Mufti, Latiff, & Amin, 2012). In Project-Based Learning, students possess their knowledge through an inquiry which is the starting point in their learning process (Bell, 2010). Similar to Problem-Based Learning, this approach is student driven and teacher’s facilitate it by giving a problem or question to a group of students (Bell, 2010; Kubiátko & Vaculová, 2011). Kubiátko and Vaculová (2011) simplified the definition as a “solution of a problem by groups of students within a specified time period, leading to the creation of a product (e.g.; thesis, report, model or etc)” (p. 66). This approach develops a student to work cooperatively and think independently (Ehrie; Kubiátko & Vaculová, 2011). On top of that, Shaffner (2003) added that Project-Based Learning is not only a new way of learning, but also an approach to work together.

Similar to Problem-Based Learning, it is an instructional method which allows students for deep learning as compared to rigid lesson plan that lead to specific learning outcome. In other words, it requires the student to be actively involved during the learning process (Kubiátko & Vaculová, 2011). Using problems in the learning process, students need to create a concrete artefact that involves designing an end product which forces students to think about all the steps involved. Thus, it allows a student to create their own pathway in the learning process. M. Prince (2004) added that the culmination of the project is

normally a written or oral report, summarizing what is done and what the outcome was. Another important feature of Project-Based Learning is the possibility of using multidisciplinary knowledge in completing their task (Kubiatko & Vaculová, 2011).

The application of a Project-Based Learning approach as compared to traditional approach, Michael Prince and Felder (2007) mentioned that “studies have yielded results that similar to those obtaining for Problem-Based Learning, including significant positive effects on problem skills, conceptual understanding and attitudes to learning” (p. 16). Meanwhile, as compared to Problem-Based Learning, many researchers believe that the Project-Based Learning approach is more suitable for engineering application (Mills & Treagust, 2003; Morris, 1996). According to Mills and Treagust (2003), this is due to the “nature of the engineering profession, which is more familiar with the concept of a project in their professional practice” (p. 13). Kubiatko and Vaculová (2011) added that Project-Based Learning is “more related to professional reality as the learning process normally takes longer than the time to complete the project given.” Besides, the implementation of Project-Based Learning is assumed to be a “directed to the application of knowledge as compared to Problem-Based Learning which is more on the acquisition of knowledge” (p. 69). Thus, it is normally used in a science subject as designing a project is relevant to this approach. Furthermore, it will engage students with authentic exploration of concept and principle in completing the learning process.

However, Nepal and Jenkins (2011) added that some engineering student dislike this approach as they need to adopt a self-directed learning in order to complete un-clear and open-ended tasks (p. 338). Besides, Mills and Treagust (2003) highlighted that students may gain less in fundamental aspect as compared to conventionally taught acquired. Moreover, he also arises on the independent skills as students might too rely on team working in completing their project given. On top of that, the effectiveness of the Project-Based Learning implementation is based on a few factors which are prior knowledge and skills, subject selection, individual learning capabilities and time management (Hsu & Liu, 2005). Michael Prince and Felder (2007) added that the challenge of Project-Based Learning is to “define projects with a scope and level of difficulty appropriate of the class, and if the end product is a constructed device or if the project involves experimentation, the appropriate equipment and laboratory shop facilities must be available” (p. 16).

#### 2.2.4. CDIO

Originated from Massachusetts Institute of Technology (MIT) America, CDIO or ‘Conceive, Design, Implement and Operate’ is another active learning approach that is designed specifically for application in the engineering discipline. It is derived from the statement that ‘engineers engineer’ and run based on specific standard syllabus that focusing on engineering fundamental in the context of Conceive, Design, Implement and Operate (Bankel et al., 2003; Crawley, 2001). The aim of CDIO is to define a specific outcome in terms of learning objectives of the person as well as necessary skills related to engineering practice (Bankel et al., 2005; Crawley, 2001). This goal then leads to a basis for designing suitable curricula that is suitable to any undergraduates engineering programme. The syllabus was also derived from various inputs from students, faculties, industries, alumni, academia, government bodies as well as professional societies.

Berggren et al. (2003) stated that “the overall goals of CDIO are:

- Master a deep working knowledge of technical fundamentals.
- Lead in the creation and operation of new products and systems.
- Understand the importance and strategic value of their future research work” (p. 49).

In CDIO, the syllabus is constructed as an integrated condensed curriculum that highlighted multiple outcomes simultaneously. In Crawley (2001), this syllabus comprises of “three levels of contents with four main expectations which are:

1. Technical Knowledge and Reasoning
2. Personal and Professional Skills
3. Interpersonal Skill
4. Conceiving, Designing, Implementing and Operating System in the Enterprise and Society Context” (p. 4)

As to date, there are revised and updated to the CDIO syllabuses since originally written in 2001 in order to add related missing requirement. (Crawley, Malmqvist, Lucas, & Brodeur, 2011).

In implementing CDIO, there are many teaching and learning methods used which is called integrated learning. According to Crawley (2007) “integrated learning means that students learn and practice personal and interpersonal, and product, process, and system building skills, while gathering technical and discipline knowledge” (p. 134). He also added that this method is effective in integrating skills with disciplinary knowledge. In addition to that, active learning methods are used in order to engage students directly in thinking and problem solving activities while experiential learning is used to engage students by setting teaching and learning contexts that stimulate engineering roles and practice. In this case, Problem and Project-Based Learning approach is used as a tool to implement the CDIO pedagogy in order to enhance the learning process (Kaikkonen & Lahtinen).

### 3. Discussion: Problem-Based Learning and Vocational Education and Training - Where does it fit?

The Chinese philosopher Confucius stressed the importance of active involvement in the learning process with his quote:

Talk to me... and I will forge  
Show me... and I will remember  
Involve me .... And I will understand  
Step back... and I will act (de Graaff & Kolmos, 2007)

This statement is a synonym to the application of active learning in the current learning environment. Even though his statement was initiated back in 500B.C, the relevance of his thought is significant in education nowadays. The traditional method of 'chalk and talk' deviates from current needs that require graduates to have multiple competencies which is a skills requirement of the 21<sup>st</sup> century. In order to achieve the target, a suitable pedagogy should be implemented parallel to the needs. Thus, the application of a Problem-Based Learning approach is believed to give a positive impact in Vocational Education and Training as it involves practical and hands-on experience. In support to that, Hanney and Savin-Baden (2013) highlight that Problem-Based Learning is a "relatively mature pedagogy, with a distinct theory of learning, that places the process of knowledge acquisition as its core"(p. 8). This approach was initially started in the 1960's for a medical field and later expanded to the engineering field where Aalborg University was one of the first to implement it (Kolmos et al., 2007). Few existing models are available in a Problem Based Learning environment proves that this approach has been well accepted across the world and many other disciplines started to adopt this approach (De Graaf & Kolmos, 2003; Hung et al., 2008; Masek & Yamin, 2010). Besides, there are many studies which reveal the effectiveness of this approach in comparison to traditional approach (Masek & Yamin, 2010; Northwood et al., 2003; Yusof et al., 2004).

In application of Problem-Based Learning in Vocational Education and Training, the underlying principle of this approach is contains in the word 'problem' itself. The use of problem at the start of the learning process is to create curiosity amongst students, encouraging them to explore the knowledge. Kollias (2011) mentioned that 'learning to learn' is another competency that should be explored as a skill among Vocational Education and Training student (p. 1). He also added that "the 'learning to learn' has nothing to do with knowledge and skills but has more of a disposition towards learning new things"(p. 1). In other words, he suggests how to cultivate intrinsic value in order to encourage for lifelong learning. Thus, curiosity embedded in a Problem-Based Learning approach can encourage deep learning as well as to motive students to go further.

Another major impact of the Problem-Based Learning approach in Vocational Education and Training graduates is the effectiveness of enhancing generic skills. As the collaborative concept is an important principle that is highlighted in this approach, the learning setting is conducted in a group rather than an individual approach in order to cultivate cooperation amongst members. Hence, the learning process in Problem-Based Learning is stimulated by discussions in small groups of student. According to Johnson, Johnson, and Stanne (2000), cooperative learning exists when students work together to accomplish shared learning goals. In this situation, team working provides a much healthier learning environment rather than creating competition amongst students. In addition to that, this approach provides students with the opportunity to prepare for professional life, by practical training through group coordination and being proficient team member. This can be achieved when students learn to co-operate amongst themselves whereby a majority of the learning processes take place in groups. Thus, this approach helps students to develop their personal growth and competencies as well as motivation towards their professional career (Kolmos et al., 2007; Nopiah, Zainuri, Asshaari, Othman, & Abdullah, 2009).

On top of that, students who are working in groups will learn and teach other and promote good relationships, improve social support and foster self-esteem (Nopiah et al., 2009; M. Prince, 2004; WORKGROUPS, 2000). In other words, the Problem-Based Learning approach helps to improve student's interpersonal skills as many studies asserted its effectiveness, particularly in the application to the engineering discipline (Ariffin et al., 2004; Yusof et al., 2004). Besides, Salleh et al. (2007) reveal that using Problem-Based Learning for students that previously used exam oriented schooling system, had gain significantly improve their generic skills development such as leadership, analytical thinking, and conflict management and etc. Surprisingly, not only the educators realise the effectiveness of this approach, most of the students seem to appreciate this new concept as they realise the positive benefit in their communication skills as well as their interpersonal skills such as self-confident (Yusof et al., 2004)

Besides, with common understanding that Vocational Education and Training is a bridge to market and the economy, it is believed that this approach is able to relate between education and the working environment. Application of real life problem in the learning process can significantly nurture their thinking skill relevant to the actual working environment (Ward & Lee, 2002). Apart from that, the use of ill-structured problems allows students to explore more on related area. In this case, the student will learn and gather information by experiencing learning through the development of a solution. Besides, it allows the student to lead their path and determine their learning direction. Thus, this will motivate them to be confident and independent (Northwood et al., 2003).

Apart from that, practical and hands-on activities already reflect 'active learning' in Vocational Education and Training context, where similar concepts of active learning can easily implement from a Problem-Based Learning approach. While 'active learning' in a Vocational Education and Training context is mainly to improve skill competencies, the application of Problem-Based Learning in the Vocational Education system can enhance students generic skills. Thus, application of the Problem-Based Learning approach in Vocational Education and Training is believed to provide better graduates both technically as well as in personal competency.

#### 4. Conclusion

Based on the finding of the discussion, the application of the Problem-Based Learning approach in Vocational Education and Training environment can improve employability skills such as interpersonal skill, communication skill, problem solving and life-long learning ability. As the aim of Vocational Education and Training approach is to provide the students with the ability to master the practical and hands-on skills, there is less concern for them to acquire factual knowledge and critical thinking as compared to academic education.

However, if technical competency is argued in Vocational Education and Training environment, there will be possible research in designing a suitable model that integrate generic skills as well as hands-on skills and technical competency. In this case Project-Based Learning is an option which is more suitable in practical application. The idea of a Problem led Project-Based Learning or Problem-oriented and project-based Learning (POPBL) is possible option to be looked at as a new learning approach as it combines Problem and Project-Based Learning principles in order to fulfill necessary competencies and requirements. In this case, important elements and characteristics of each approach can be used as the main backbone in designing the model with regards to Vocational Education and Training application.

Thus, it is concluded that the application of active learning particularly the Problem Based Learning approach, to enhance employability skill among vocational students. This new paradigm in the education system is hoped to produce students that comply with 21<sup>st</sup> century skills requirements, which is also the ultimate aim of all learning and teaching methods.

#### 5. Tables

Table 1: Characteristics of traditional learning and Problem-Based Learning.

Adapted from Barrows (1996) cited in Grigg and Lewis (2013)

	Traditional	PBL
Role of the tutor	Lecturer	Facilitator or guide
Curriculum	Subjects	Problems
Audience disposition	Passive	Active
Organisation	Large classes	Small groups
Approach	Tutor-directed	Self-directed

#### Acknowledgements

The author would like to thank Dr. Robin Clark and Dr. Jane Andrews for their guidance through the paper development.

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