The Effectiveness of Problem-based Learning Approach on Students’ Skills in Technical Vocational Education and Training (TVET) Specifically on Programming Course Using a Computerized Numerical Control (CNC) Simulator.

Hashim Mohamad a *, E. de Graaff b

aGerman-Malaysian Institute, Taman Universiti, 43000 Kajang, Selangor Malaysia  
bUNESCO Chair in PBL in Engineering Education, Aalborg Universitet 9000 Aalborg, Denmark

Abstract

Industry has a great need for highly skilled technicians that graduate from Technical Vocational Education and Training (TVET). In a study started at Aalborg University (AAU) the purpose is to evaluate the effectiveness of the (PBL) approach on students’ skills, in particular on programming course using a Computerized Numerical Control (CNC) simulator. The study will use data from the German-Malaysian Institute in Malaysia. The findings of this study will provide a general guideline for educators in Technical and Vocational Education and Training (TVET) institutions in implementing Problem-Based Learning (PBL) at Diploma level of the students. In this paper we will present the research method which will be used to address the research questions. The research methodology used in this study is mixed methods with combination of qualitative and quantitative approaches during different phases of research process.

Keywords: Evaluate; Effectiveness; Technical Vocational Education and Training; Problem-based Learning;

1. Introduction

1.1. Research Background

The German-Malaysian Institute established in 1991 has more than 21 years in operation as a technical and vocational training institute. The institute aims to support the Malaysian industries by producing highly skilled and competent technicians/technologist that are able to operate modern technologies efficiently. This is in line with the government’s Third Industrial Master Plan (IMP3) which emphasizes improvement of the number and quality of skilled workers who could respond to the changing environment and enhancing competitiveness.

Recently, the German-Malaysian Institute (GMI) had changed the training approach for some courses from a teacher-centred to a student-centred approach by implementing PBL. Typically, technical and vocational subjects are delivered using the traditional four step method training approach: describe, demonstrate, try-out by trainee and evaluate with feedback. In technical and vocational training, students need to acquire technical skills through hands-on-work that enables them to solve authentic problems from industry. However, students trained with this traditional approach lack some generic skills such as problem solving, critical thinking, communication and leadership. In order to transform the traditional training approach to PBL, GMI had adapted the model (figure 1) introduced by Neo T K & Neo M, (2005).

With PBL, Technical Training Officers (TTO) and students are required to change roles. TTO acts to facilitate the learning rather than to provide knowledge. The students have to engage in an active learning process help them develop flexible knowledge, problem-solving skills, self-directed learning skills, collaboration skills and intrinsic motivation (Hmelo-Silver, 2009). The PBL approach requires the students to be self-directed or self-regulated with respect to their own learning process.

* Corresponding Author: Hashim Mohamad  
E-mail address: hashim@gmi.edu.my
In order to materialize the change of the teaching approach from traditional methods to PBL in the German-Malaysian Institute (GMI), a group of 25 Technical Training Officers were exposed to PBL trainings and workshops in Republic Polytechnic, Singapore in 2008. Furthermore, a number of Technical Training Officers were also sent to universities overseas to further their study in PBL. For the same reason, a PhD study is initiated aiming to evaluate the effectiveness of PBL approach to TVET. The study was positioned at the UNESCO centre for PBL at Aalborg University in Denmark, a well-known centre of expertise on PBL.

This study will have the data collected at the German-Malaysian Institute with students at Diploma level of Technical Vocational Education and training (TVET). The purpose of this study is to evaluate the effectiveness of PBL approach on GMI’s students’ skills on programming course using a Computerized Numerical Control (CNC) simulator. The study will be conducted with groups of GMI’s students at Diploma level and teaching staffs (facilitators) for a period of 6 months. The big question is how to demonstrate the effectiveness of the alternative approaches (PBL) as far as the students’ skills in Technical Vocational Education and Training (TVET) is concerned. In this paper we will present the research design aiming to address the research questions. The study will use mixed methods, a combination of qualitative and quantitative approaches during different phases of research process. The findings of this study will provide a general guideline for educators in Technical and Vocational Education and Training (TVET) institutions in implementing Problem-Based Learning (PBL) specifically on part programming using CNC simulator by Diploma level of the students. The potential benefit of this study is the answer to research questions how effective the PBL approach to TVET.

1.2. Research Overview

This study is a PhD project situated at Aalborg University (AAU), Denmark. This study will have the data collected at the German-Malaysian Institute with students at Diploma level of Technical Vocational Education and training (TVET). The purpose of this study is to evaluate the effectiveness of PBL approach on GMI’s students’ skills on programming course using a Computerized Numerical Control (CNC) simulator. The study will be conducted with groups of GMI’s students at Diploma level and teaching staffs (facilitators) for a period of 6 months. The big question is how to demonstrate the effectiveness of the PBL approaches as far as the students’ skills in Technical Vocational Education and Training (TVET) is concerned. In this paper we will present the research design aiming to address the research questions. The study will use mixed methods, a combination of qualitative and quantitative approaches during different phases of research process. The findings of this study will provide a general guideline for educators in Technical and Vocational Education and Training (TVET) institutions in implementing Problem-Based Learning (PBL) specifically on part programming using CNC simulator by Diploma level of the students.

1.3. Problem-Based Learning

The significance for GMI to Implement the Problem-Based Learning in its Technical Vocational Education and Training is to enhance students’ learning skills which include the methodological skills and energy to continue learning independently after training at GMI. According to a study by Bridges (1992), PBL approach triggers the students’ learning and they become highly motivated, they enjoy the activities they do, appreciate the value of what they learn, consider about how they will use their newly acquired knowledge and skills in the real situation in future and experience sense of achievement upon completion of a project. The students cannot continuously be spoon-feeding in acquiring knowledge but they should be exposed to “learn how to learn” to help them cope with demands of a rapidly changing and competitive working environment. The technical training provider should develop learning opportunities that help students develop problem solving skills and lifelong learning. Bridges (1992) underlined four major goals of PBL: (1) acquisition of the knowledge base underlying administrative practice, (2) development of administrative skills, (3) development of problem-solving skills, and development of lifelong learning skills. The employers in the industries wanted students who could think critically, solve problems and work in teams with other employees. Furthermore, students in the problem-based learning environment have developed stronger clinical competencies although the differences were small and non-significant (de Vries, Schmidt, & de Graaff, 1989). Problem-Based Learning is an educational strategy and a method to organize the learning process in such a manner that the students are actively engaged in finding answers by themselves (Graaff and Kolmos, 2007). Learners in this environment play an active role in the knowledge acquisition process by attempting to solve ill-structured problems through participation in small group discussions and self-study (Albanese, 1993). The learning is triggered by offering ill-structured problems, providing a more realistic approach to learning and creating an educational method which emphasizes real world challenges, higher order thinking skills, multi-disciplinary learning, independent learning, teamwork and communication skills (Schmidt, 2005). Self-Regulated learning is ubiquitous in research on education nowadays and it is an umbrella term for various processes such as goal setting, metacognition, and self-assessment, all of which influence learning in various ways (e.g., Boekaerts 1999; Paris and Paris 2001; Zimmerman 1989). The criteria for effective teaching and learning are all fostered in small group interactions especially in PBL. Small group teaching depends more on the characteristics displayed by that group rather than the numbers in it. Therefore, the aim of a small group session should be to encourage students to adopt deep approach towards learning and to be a self-directed active learner (Walton, 1999). PBL is an approach in learning and instruction in which students tackle problems in small group under the supervision of a tutor (Schmidt, 1983). The principal idea behind PBL is that the starting point of learning should be a problem, a query that the learner wishes to solve (Boyd, 1985). Students work on the problem to identify and search for the knowledge that they need to obtain in order to approach the problem (Davis & Harden, 2005). To assist students to be effective in their learning, teachers should help students become aware of alternative ways of approaching learning situation (McKeachie, 1988), but Weinstein and Mayer (1986) suggest that learning
strategies appropriate for one type of learning situation may not be appropriate for another. It is important to prepare students for self-directed learning and the PBL process by conducting and orientation at the beginning of the course or program (Ong, 2006). “PBL is a different concept that not many people have heard of. It is important for the school to communicate the purpose to all staff and students; otherwise, both teachers and students will be left in the dark, only to group for the rationale” (Yeo, 2005). Weizman (2008) had underlined several components in order to be successful in applying PBL approach. The components include:

- Strong conceptual understanding of subject matter.
- The ability to apply knowledge in new or unanticipated contexts for problem solving.
- The ability to reason with incomplete information and make decisions that will be the best for the class as well as for individual students.
- Motivation for self-directed learning to stay apprised of current thinking within their subject matter.

1.4. PBL’s Effectiveness

Many studies had been made on the effectiveness of PBL implemented in medical education, engineering, higher education and etc. These findings had shown the positive effect on the students’ behaviour toward learning. Learning styles is broadly described as the cognitive, affective, and physiological behaviours that are relatively stable indicators of how learners perceive, interact with, and respond to the learning environment (Keeffe, 1979). Studies had also shown that the students who acquired knowledge by solving problems (PBL) more likely to use it spontaneously to solve new problems (Bransford, Franks, Vye, & Sherwood, 1989). PBL approach is proven to be very effective in educating and propagating learning among students. However, the successful of PBL implementation apparently depend on many factors that will influence the effectiveness of PBL approach. In the context of this study, the factors that might influence the effectiveness of PBL implementation are the PBL curriculum design, material development such as the quality of problem crafting, student PBL orientation and teacher’s facilitation skills. However, in this study, the researcher measures the effectiveness of PBL is based on the learning outcomes from the programming course using a Computerized Numerical Control (CNC) simulator which is the knowledge, hand-on skills and key qualifications such as presentation skills, communication skills and etc. The findings from the research questions will also be taken into consideration to evaluate the effectiveness of PBL in this study.

2. Research Methodology

The expected outcome of the study is a general guideline for educators in Technical and Vocational Education and Training (TVET) institutions in implementing Problem-Based Learning (PBL) specifically on programming course using a CNC simulator by Diploma level of the students. Hopefully, the guideline will be also applicable for educators to implement PBL for students in any TVET discipline at certificate level. In order to achieve this outcome, several comprehensive studies on current practise PBL approach in TVET will be conducted.

At this stage we employ the mixed methods design comprising qualitative and quantitative methods approaches in order to obtain data from the current practise of the PBL group’s participants (Students and Teaching Staffs). This research will use the concurrent mixed methods approach in which the researcher converges or merges qualitative and quantitative data in order to provide a comprehensive analysis of the research questions (Creswell, 2007). Both forms of data will be collected at the same time and then integrates the information in the interpretation of the overall results (Creswell, 2007). In the qualitative methods of data collection, the teaching staff will be asked to gather data on verbal and non-verbal during the class session, students’ interactions, students’ reflection, students’ learning skills & attitudes and problem-solving skills. The interviews will be used to explore students’ perceptions about Problem, Project and Production-Based Learning as well as those of the teaching staff and educational management. The questionnaire will be the instrument to survey each student’s perception about PBL approach. Learning experiences recorded by the questionnaire will be used to validate the data collected from the interviews. The content analysis will be used to analyse students’ findings and justifications to a problem for their problem solving skills. The combination of qualitative and quantitative data provides a thorough understanding in addressing the research questions below, in particular to provide complementary qualitative data if quantitative data are inadequate (Creswell, 2007). The quantitative methods of data collection will be through: (1) pre-tests, (2) post-tests and (3) practical test. The students will be subjected to these instruments to evaluate on their learning skills and hands-on skills and this will also serve to validate the data that will be collected through a qualitative approach. Throughout the research, the researcher may embed one smaller form of data within another larger data collection in order to analyse different types of questions in which the qualitative addresses the process while the quantitative, the outcomes (Creswell, 2007).

2.1. Research Questions:

At the start of the research project the following research questions were formulated:

1. How do GMI/AAU students perceive the concepts Problem, Project and Production-Based Learning approach for TVET?
2. To what extends do the learning facilities and infrastructures in GMI influence the effectiveness of the PBL implementation in TVET?
3. What typical activities take place in the PBL learning environment?
4. To what extend does the PBL approach promote students’ (GMI) learning skills in TVET specifically on programming course using CNC simulator?
5. What kind of learning experiences contributes to the professional development of highly skilled technicians?
6. To what extends do the students’ (GMI) academic backgrounds influence the effectiveness of the PBL implementation in TVET?
7. To what extents do the students’ (GMI) learning attitudes influences the effectiveness of the PBL implementation in TVET?
8. To what extents do the students’ (GMI) problem-solving skills influences the effectiveness of the PBL learning in TVET?
9. To what extends do the GMI students’ benefits from the CNC simulator in the PBL approach?

In order to achieve the desired outcome, this study needs to do research on a variety of PBL approaches such as Product, Project, or Production Based Learning. Eventually, this will allow researcher to come to a conclusion which PBL approach is most appropriate to be used in TVET. The main concern in TVET is to develop hands-on skills and the main concern in PBL is the development of skills such as critical thinking, problem solving, learning and etc. This study is also aiming to find a compromise between both the traditional and the PBL approach in developing hands-on skills in TVET. In other words, it is a combination of both.

3. Discussion and conclusions

3.1. Discussion

The expected outcome of the study is to develop a general guideline for educators in Technical and Vocational Education and Training (TVET) institutions in implementing Problem-Based Learning (PBL) specifically on programming course using a CNC simulator. In order to achieve the desired outcome, this study needs to do research on a variety of PBL approaches such as Product, Project, or Production Based Learning. Eventually, this will allow us to come to a conclusion which PBL approach is most appropriate to be used in TVET. The main concern in TVET is to develop hands-on skills and the main concern in PBL is the development of skills such as critical thinking, problem solving, learning and etc. This study is aiming to find a compromise between both the traditional and the PBL approach in developing hands-on skills in TVET. In other words, it is a combination of both.

The primary data collection will be done in the German-Malaysian Institute in Malaysia. Still, the possibility to compare some aspects of the PBL implementation in Aalborg University in Denmark with GMI in Malaysia is under consideration. Presently nine research questions are formulated as focus of this study. However these research questions will have to be narrowed down as the research progresses. Hence, there will be a process of reformulation on the research questions and elaboration of the research design. The data collection of this study will emphasize the PBL approach rather than the traditional approach, because GMI already has the statistic of students’ results trained in traditional approach. This study (research question 6) also concerned with the low achievers (GMI’s students) in academic background as this will indirectly influence the effectiveness of PBL in TVET. With respect to this study some limitations have been identified that are supposed to affect the findings of this study. These limitations are the followings:

1. The sample of this study will be teaching staffs and students from GMI comprising 6 groups of 4 per group as the grouping of students per class is 24 students.
2. Restricted to the technical and vocational education training which emphasize hands-on skills for students at Diploma level specifically on programming course using CNC simulator.
3. Difference in the level of prior knowledge of each student.
4. The level of education background of each student may be different because they come from various schools, technical schools, technical institution and technical college.

3.2. Conclusion

The potential benefit of this study is the answer to research questions how effective the PBL approach to TVET. Even if this study perhaps might not answer all research questions, it will trigger more studies on the PBL effectiveness in TVET in the future. TVET education is highly essential especially in the Malaysian context as Malaysia is moving towards an industrialized country and the responsible of the TVET institutions to produce highly skilled and competent technicians/technologist to support Malaysian industries. Presently, the development of human capital with multiple competencies is in great demand and personnel
with only one technical competency is no longer competitive and will not survive in the globalization era (Ngan C. H., 2010). GMI had taken an important step forward to change the TVET training approach from traditional to PBL approach. This study will hopefully benefit not only to GMI but also to all TVET institutions in Malaysia. The significance of this study is to provide tool to the technical and vocational training providers particularly in Malaysia or countries with similar conditions, as the general guideline that will be produced will help them to develop and implement PBL at their training institution. Hopefully, this study could contribute to better and effective of PBL implementation in TVET and increase the learning skills of students as well as their hands-on skills to prepare them for a challenging working environment.

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