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Assessing the Implementation of the Project-Based Learning (PJBL) in the Department of Mechanical Engineering at a Malaysian Polytechnic

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Abstract: Even though Project-Based Learning is sound in theory but the implementation of this student-centred approach is often problematic due to varied factors. Hence, the aim of this research was to evaluate the effectiveness of the implementation of Project-Based Learning at a polytechnic in Malaysia. The research design used in this study was program evaluation. Program evaluation is systematic method to determine the effectiveness and efficiency of a program. A CIPP model was selected because it is a holistic and appropriate model for program evaluation. In terms of sampling, 43 supervisors and 118 students were selected randomly. The main instrument used in this study was a set of questionnaires validated in a pilot study. Key finding shows that most supervisors and students believe that Project-Based Learning is suitable for the students' senior project. They also believe that the supervisors possessed adequate technical knowledge and have implemented their supervisory duties effectively. However, the students perceived that the content of the Project-Based module was hard to follow and the students lack of creativity. The facilities in the polytechnic were also not optimal for the final project. Based on the empirical data, this study contributes a new framework for Project-Based Learning.

Keywords: Assessment, Project-Based Learning, Malaysian Polytechnics, CIPP, e-SOLMS

1. Introduction

Robust economic competitiveness requires an innovative workforce. Advanced economies have a higher number of knowledge workers (K-workers) as compared to developing and third world countries. Creativity and inventiveness are the two main characteristics of an innovative workforce. Thus, linking education to economic development is critical in producing first-class human capital (Ramlee, 2013; 2017). A new type of education that emphasizes Project-Based Learning (PjBL) is needed to produce creative graduates. Hence, authentic Project-Based Learning is an empowered option for the education system to excel. Project-Based Learning is derived from autonomous learning in a conducive environment via an authentic inquiry that requires creative solutions. Also, creativity and inventiveness are essential in Project-Based Learning. In comparative studies between East and West, several scholars (Akoojee, 2016; Ng, 1999; Hannas, 2003; Lau et al., 2004; Kim, 2005) tend to agree that Asian students are less creative than students in the western countries. Promoting creativity in the classroom is an ingenious effort that involves the introduction of novel ideas into an established domain as such threaten the conventional way of doing things especially in Asia (Ng, 1999). Hence, a nation's philosophy, ideology and culture play an important role in determining an innovative workforce.

Rapid changing of the world of work has affected the traditional curricula. More knowledge and skilled workers in new sectors are needed. But the industry is facing problems getting such skilled workers due mainly to training mismatch (Leyden, 2008). There are weak links between educational institutions and industry (Ramlee, 1999; 2013;

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2017). The education and training system is not producing adequate K-workers required by the industry (NEAC, 2010). The skills mismatch and skills shortage has prompted the government to study the suitability of the curriculum and training systems that need to be reformed to fulfill industrial needs (Fong, 2007). Nevertheless, the mismatch persists due to the lagging of curriculum reforms. In Asia, a considerable number of countries still use outdated TVET curricula and facilities. Poor quality of training facilities and infrastructure in vocational institutions cannot match the latest facilities in the industry.

In brief, the traditional teaching and learning paradigm is still widespread in TVET institutions. This paradigm focuses on a teacher-centered approach. Noraini (2009) stated that the teacher-centered approach has several shortcomings, for instance, static and passive students' learning due to the teachers' belief that the gurus are the sage on the stage. Little creativity or innovation is allowed – everything should follow the syllabus and ought to focus on finishing the syllabus on time – regardless of the students learn or not. Most of the time, the students are asked to regurgitate back whatever the teachers have said. Hence, the traditional pedagogy is imbued with mental slothful and lackluster ambiance. Effective learning would create more active students both in or outside the classroom. But frequently it does not happen when students are too dependent on the teacher. Hence, students sometimes feel bored when learning is centered on the teacher (teacher-centered learning). Teachers spend a considerable focus on the topic of teaching that prepares students for examinations, teachers are more focused on teacher-centered learning rather than student-centered learning (Noraini, 2009). Moreover, in the traditional teacher-centered classroom, students tend to keep quiet because they are not encouraged to ask questions even if they do not understand what the teacher says. Hence, most students learn the knowledge indirectly or only following their peers. Middlebrooks and Slupski (2002) stated that students easily become bored and less motivated to learn because they do not understand the purpose, meaning, and learning applications.

Boredom could be alleviated if students are given the chance to actively participate in the learning process. New learning models are introduced as alternatives to traditional rote learning and passive paradigm of "tabula rasa". Active learning and constructivist philosophy of learning is the bedrock of a new learning approach including Project-Based Learning (Grant, 2002; Karlin & Vianni, 2001). Project-Based Learning has progressed as a dynamic learning approach that integrates multiple skills in completing a challenging real-world project. The nature of actual problem-solving is open-ended which requires creative and optimal solutions (Donnelly & Fitzmaurice, 2005). Authentic project-based demands the trainees to think and solve the problem like real professionals (Boss, 2011). The project-Based Learning approach is interdisciplinary. As such, supervisors and trainees may consult other experts to solve the problem and complete the project (Railsback, 2002). Besides emphasizing high-order thinking, Project-Based Learning also accommodates group members with different learning styles and abilities. In short, Project-Based Learning stresses on individual and group learning through dynamic interaction and collaboration. Based on the weaknesses of the conventional teacher-centered paradigm that lacks authenticity and creativity, Project-Based approach is preferable and already being implemented in the final-year project course in Malaysian polytechnic system since 2008 (Md. Baharuddin et al., 2008; 2011; Mohd Noramdzan et al., 2014; Nor Khayati Basir et al., 2017). However, the effectiveness of the PjBL in the polytechnic has not been studied comprehensively. Hence, this study was designed to evaluate the effectiveness of the implementation of the final-year project using Project-Based Learning approach (PjBL) in the Department of Mechanical Engineering at a Malaysian Polytechnic.

2. Related Works

Constructivism is not a new theory in pedagogy. The theory rose from the main shortcoming of behaviourist theory that disregards a child's ability to construct his/her knowledge. Scholars such as Jean-Jacques Rousseau, John Dewey, and Jean Piaget and the current constructivists, believe that a child is active in learning and he/she could scaffold his/her knowledge. Project-Based Learning also emphasizes discovery learning by focusing on the process of discovery (Duffy & Cunningham, 1996). Project-Based Learning mainly evolves from the work of two influential psychologists: Jean Piaget and Lev Vygotsky (Wikiversity, 2011). Piaget was known as the first cognitive scholar who asserted that knowledge is constructed in the mind through assimilation and accommodation process. However, Vygotsky criticized Piaget's theory. Piaget emphasize intellectual or cognitive development while Vygotsky stressed on the social environment. However, few teachers teach in a pure didactic manner or a pure constructivist manner. Some teachers use both approaches (didactic and social constructivism) ─switching from one to another (Moursund, 2009).

Project-Based Learning is assumed to be an effective teaching and learning method especially in technical institutions such as polytechnics. In Malaysia, public polytechnics system has been established since 1969. In 2012, a total of 87,440 students enrolled in polytechnics as compared to 60,840 students in 2009 (Sahul Ham et al., 2010). The growing number of students joining polytechnics is making the system as one of the largest technical education providers in Malaysia. To cope with contemporary challenges, Polytechnics Transformation Plan was launched in 2010 with these emphases (Department of Polytechnics Education, 2010): (a) to spearhead polytechnics as a preferred training institution in technical and vocational areas in the semi-professional sector, (b) to continuously assess the relevance of the polytechnics programs to the needs of the industry, (c) to strengthen the niche technology areas to produce marketable graduates, (d) to enhance polytechnics ranking, and (e) to offer new competitive programs.

Based on the Economic Transformation Plan (ETP), Malaysia desires to attract foreign students to study in Malaysian higher education institutions – either public or private. In 2014, a total of 35,592 foreign students were studying in Malaysian universities and colleges (UNESCO Institute for Statistics, 2016). If combined with foreign and local students, there are about one million tertiary students in Malaysia. Educational and training institutions are the gateway to graduate employability. Malaysia puts a relatively high amount of public funds into the education sector as compared to other Asian countries (Ministry of Education, 2012; Khaled Nordin, 2013). With a population approaching 30 million people, Malaysia has 20 public universities, 26 private universities, 23 private university colleges, 28 polytechnics, 74 community colleges, 434 private colleges and several branch campuses of foreign universities based on 2011 statistics (www.moe.gov.my/).

TVET is one of the various disciplines of education that can play a crucial role in promoting sustainable economic growth and socio-economic development of a nation (Mclean, Jagannathan & Sarvi, 2013; Peter et. al., 2016; Ramlee, 2017; Ramlee & Greenan, 2002; Ramlee &Abu, 2004; Ramlee & Norani, 2007; Ramlee & Norhasni, 2008). The emerging of the innovation-led economy requires more creativity on part of the workers to generate new ideas, services or products. Innovative ideas could spring forth by solving a challenging problem or by completing a real-world project. Project-Based Learning is embedded in most TVET curricula. Project-Based Learning stresses on knowledge construction derived from previous knowledge, experience, and interaction with the social environment. Besides, advocates assert that Project-Based Learning prepares students for creative work, critical thinking and effective teamwork as required in the real workplace (David, 2008). In brief, Project-Based Learning was introduced because of the deficiency of the traditional pedagogy. Hence, Project-Based Learning is a powerful tool to enhance creativity and innovation. In the Malaysian polytechnics, Project-Based Learning has been implemented since 2008 (Md. Baharuddin et al., 2008; 2011; Mohd Noramdzan et al., 2014; Nor Khayati Basir et al., 2017). This final-year senior project-based learning course (J5012) is a group project designed to assess the students' competencies in Mechanical Engineering. In this one-semester project, each group is assigned with one supervisor (polytechnic lecturer) to guide the students. The final assessment of the project will be graded by a jury after the students' project demonstration.

The philosophy of active learning, student-centered and group dynamics is embedded in Project-Based Learning. Project-Based Learning involves mind and hands. Inauthentic Project-Based Learning, students are given a real problem or actual situation in which they are asked to find the solutions by gathering various inputs from books, journals, handbooks, manuals, brochures, the Internet and so on. Teachers only act as guides or catalysts to the students. In addition, several researchers believe that technology enhances Project-Based Learning (Moursund, 2002). Technology plays a dynamic role in making the knowledge construction process explicit, thereby helping learners to become aware of that process (Jonassen et al., 1999). Kivunja (2015) argues that technology makes the environment more authentic to students because, among others, the computer provides access to data and information and expands interaction and collaboration with others via digital networks.

In polytechnics, technology-based learning environments are designed to support advanced knowledge acquisition. And that can be done by providing environments and thinking tools that engage the constructivist conception of learning (Kommers, Jonassen, & Mayes, 1992). Thinking tools are technology systems or applications that extend the intellectual functionality of the learner by engaging the learner to tasks that facilitate knowledge construction. Even a simple Internet tool, for example, could add critical and valuable dimensions to enhance Project-Based Learning. Another advantage of digital technology, the Internet ─ is that access to information on other projects is open to wider audiences. More specifically, students have the opportunity to examine, review and browse other similar projects–thus, giving them a myriad of ideas to embark on their project. In sum, digital technology has changed the traditional way of teaching (Kwek, 2011).

In the Malaysian polytechnics system, e-Students Learning Management System (e-SOLMS) is used in tandem with Project-Based Learning. The system was designed by Universiti Sains Malaysia (Md. Baharuddin et al., 2008; 2009; 2011). Most importantly, the web can be used as a communication and collaboration medium to build ongoing dialogues between the project participants and their supervisor. These "students-mentor" dialogues can be planned and organized to facilitate learnings and trouble-shooting. A networked project typically involves students in distant locations cooperating to research, exchange information, and learn from one another, although the distant partners may include experts. Students may conduct research, perform experiments in their community, and report their findings. They may pose questions to experts or exchange information with their peers.

3. Problem Statement

Employers lament on graduates' competencies, especially those employees who lack innovation and high-order thinking skills (Lowden et al., 2011). Innovation is weak in most Asian countries (Lohani, 2013) due to a lack of "new" knowledge and capacity to innovate. Most of the new knowledge usually derived from creative discoveries and scientific breakthroughs originated from Western countries. Malaysian education system relies heavily on memorization of the facts. Conventional teaching and learning methods have suppressed the creativity of the students. The traditional teaching method notably assumes students are a passive recipient of knowledge and the teacher should spoon-feed the students. Hence, it is different from Project-Based Learning, where teachers act as a facilitator of learning. Project-Based Learning is an approach that transforms teaching from "teachers telling" to "students doing"

(El Kamoun et al., 2011). In Project-Based Learning, students become active problem-solvers and meaning-makers. Further, the students collaborate or cooperate by forming groups, organize their learning activities, conduct research, synthesize information, organize time and reflect their learning. In Project-Based Learning, a teacher is not "sage on the stage"; but rather a "guide on the side" and assumes the role of cognitive and meta-cognitive coach (by asking, monitoring, probing, managing, group relating, keep moving) rather than knowledge-holder and disseminator (Schneider, 2005). According to Quah et al, (2009), university students in Malaysia lack creativity. The low level of creativity among Malaysians could be a stumbling block for the nation that hopes to achieve an advanced country status in 2020. In the innovation-led economy, a new type of workforce is required.

To fulfill the need of the industries, the real working environment requires a workforce with the right skills. Ramlee et al., (2002; 2004) stated that employers in the manufacturing industry in Malaysia believed that the technical graduates possess technical know-how but inadequate of generic or transversal skills such as critical and innovative skills, inter- and intra-personal skills, entrepreneurial and problem-solving skills. The National Employers Skills Survey (2003) reported that several employers in England complaint about the lack of these transversal skills in the employees: communication, customer-handling, teamwork, and problem-solving. The mismatch between the supply and demand for a skilled workforce needs to be addressed more comprehensively through a more structured academia-industry collaboration, especially in the critical areas such a curriculum development and industrial training (Malaysia, 2006). Productivity and Investment Climate Survey (PICS) 2002/2003 (cited in Yogeesvaran, 2005) also found that the shortage of critical skilled workers as the main problem faced by a majority of the firms surveyed. The issue of skills mismatch is seen as the weakness of education and training institutions in providing suitable human resources that satisfy the requirements of the industry (Yogeesvaran, 2005). The mismatch is detrimental to the external efficiency of a country's economic development (Cao, 2010). Economic development could be improved if the education system is relevant to the labor market.

Project-Based Learning tends to be a relevant approach for TVET. According to Buck Institute for Education (2011) and Lipson et al. (2007), Project-Based Learning is an innovative teaching method that engages students in active learning by solving a real-world problem and integrating multiple skills through a student-led inquiry process. Besides, Project-Based Learning requires collaborative investigation in producing an artifact or a product (Blumenfeld et al., 1991). Nevertheless, Project-Based Learning is relatively challenging to plan and implement due to its complexity. The other disadvantages of Project-Based Learning are the high cost and time-consuming. Subjectivity in the assessment of Project-Based Learning is another delicate issue. Hence, the real effectiveness of the method is questionable. However, empirical research in this area is scarce. Therefore, this study was designed to evaluate the effectiveness of Project-Based Learning at one of the polytechnics in Malaysia by using the modified CIPP (Context, Input, Process, and Product) model.

4. The Conceptual Framework

Program evaluation is critical to improving the content and the implementation of a system. This evaluation study was conducted to evaluate the efficiency of Project-Based Learning at a Malaysian polytechnic. The CIPP model by Stufflebeam (1971; 2002) was selected as the conceptual framework in this empirical study. The CIPP evaluation model was chosen because it was a versatile program evaluation model across a wide range of applications. It could enhance our understanding of the design process and may offer insight into which areas could be improved in future undertakings. Figure1 shows the conceptual framework that focuses on three main domains ─ input (I), process (P), and product (P). The context (C) domain was excluded in this study because all public polytechnics in Malaysia have the same context and the same standard curricula. One of the limitations of the study is that we did not include the context domain due to the common curriculum and subject codes offered throughout polytechnics in Malaysia due to MQA requirements.

Based on Blumenfeld et al., (1991) and Mergendoller and Thomas (2000), the input domain focuses on the Project-Based Module and the supervisor's readiness. Next, the process domain consists of finding the idea, problem-solving, time management, and knowledge improvement (Mergendoller & Thomas, 2000). Finally, product design and product quality are the main indicators in the product dimension as proposed by Barak and Dori (n.d.).

The purpose of this evaluation research was to determine the efficiency of the Project-Based Learning (Final Project course) as perceived by the students and their supervisors at a Malaysian polytechnic. Specifically, the research questions of this study were:

i. What are the significant differences in the input dimension of the Project-Based Learning as perceived by the students and their supervisors?
ii. What are the significant differences in the process dimension of the Project-Based Learning as perceived by the students and their supervisors?
iii. What are the significant differences in the product dimension of the Project-Based Learning as perceived by the students and their supervisors?
iv. What are the factors that influence the efficiency of Project-Based Learning?
v. What is a new framework for Project-Based Learning that could be proposed?

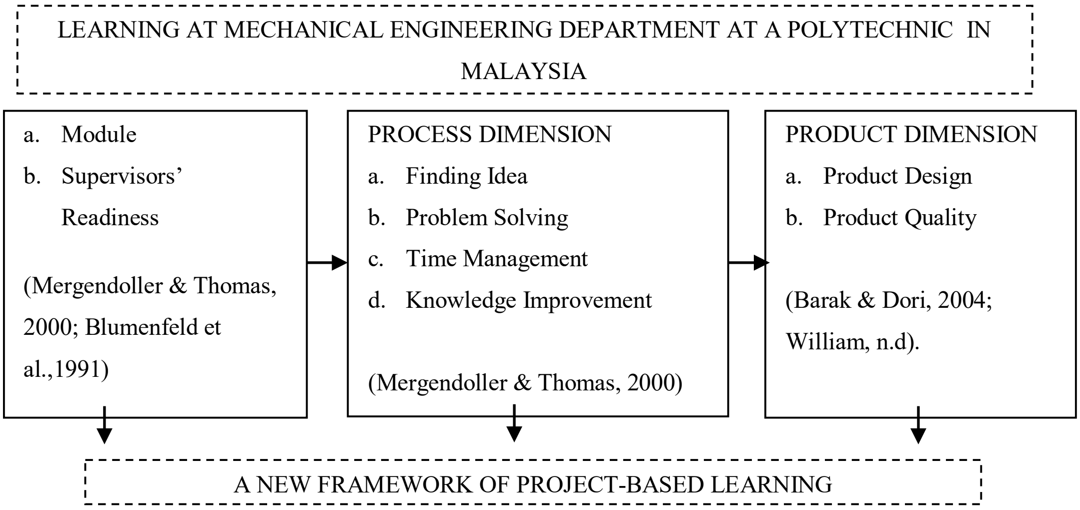

Fig.1 - The Conceptual Framework

4.1 The Null Hypotheses

Ho1 : There is no significant difference in the input dimension between students and supervisors.

Ho2 : There is no significant difference in the process dimension between students and supervisors.

Ho3 : There is no significant difference in the product dimension between students and supervisors.

5. Methodology

This evaluation research was designed to assess the perception of students and supervisors regarding Project-Based Learning at a public polytechnic. This study used Stufflebeam's CIPP (Context, Input, Process, and Product) evaluation, model. This model was modified in which the context dimension was excluded due to the same context for all public polytechnics in Malaysia. Based on Stufflebeam's model as illustrated in Figure 1, the input dimension consists of the Project-Based module and aptness of the supervisors. The teaching and learning process was identified as the process dimension. And lastly, the product dimension was measured by the quality of the students' final product.

There were two target populations in this study. The first population was final-project course' supervisors in the Mechanical Engineering Department in the selected polytechnic. The second population was the final-semester students who were completing the final-year project. Based on Krejcie and Morgan's sample size formula, a population of 170 would be represented by a sample of 118 respondents. The random sample of 70 students was selected from Agricultural Mechanical Engineering (DPT), 42 students were selected from Automotive Mechanical Engineering (DAD), and 6 students were selected from Mechanical Engineering Program (DEM). The sample consisted of 118 students who were perceived to be adequate based on the Krejcie and Morgan (1970) sample size table. As mentioned earlier, a population of 76 supervisors was identified. However, only 43 supervisors were willing to participate in the study. Since the samples were selected from only one polytechnic so the results from this study have limited generalization. The findings cannot be generalized to all polytechnics in Malaysia.

Before conducting the pilot test, the questionnaires were validated by three experts specializing in engineering technology. The draft instruments were modified based on the experts' recommendations. The pilot study was conducted on 20 students and 10 lecturers. The Alpha Cronbach coefficients were determined by analyzing the pilot study's data. The coefficients were found to be high, ie., between 0.70 and 0.94. Thus, the instruments were considered valid and reliable.

6. Results

Table 1 shows the Input Dimension. For item L1, the students believed (M=3.79; SD=0.82) that Project-Based Learning is appropriate for the final-year project course J5012. Most of the respondents were confident (M=3.73; SD=0.83) that they were able to start their project by using a Project-Based Learning approach (L2). In item L3, the students believed (M=3.70; SD=0.85) that the module was designed based on the Project-Based Learning model. Concerning student activity in the module (item L4), the students agreed (M=3.80; SD=0.85) that they followed the module in completing their project. Nevertheless, the students barely agreed(M=3.59; SD=0.72) that they understand the content of the module (item L5). In terms of the weekly goal setting, the students believed (M=3.76; SD=0.83) that the procedure has assisted them to be savvier (item L6). Finally, the students admitted (M=3.89; SD=0.92) that though the project was challenging at first they had gradually succeeded to complete the project (item L7). Item L7has shown a high standard deviation which suggested polarized responses.

Table 1 - Input Dimension (The Modules) of Project-Based Learning perceived by Students (n =118)

	Items	M (ME)	SD	Interpretation
L1.	In my opinion, Project-Based Learning approach was appropriate for project course.	3.79 (0.07)	0.82	Agree
L2.	With Project-Based Learning, I am confident to start my project.	3.73 (0.07)	0.83	Agree
L3.	Project management module was designed based on Project-Based Learning approach.	3.70 (0.07)	0.83	Agree
L4.	Students' project activity was based on the project module.	3.80 (0.06)	0.85	Agree
L5.	Project management module content was easy to understand.	3.59 (0.09)	0.72	Agree
L6.	Weekly goal setting has helped me to focus on what to be accomplished.	3.76 (0.07)	0.83	Agree
L7.	Initially, I found project course J5012 was a challenge, but the project succeeded by using this module.	3.89 (0.08)	0.92	Agree
	Total average	**3.75**	**0.83**	

In terms of supervisors' readiness, items L8 through L10 (see Table 2) were formulated to identify the students' perceptions regarding their supervisors' readiness for Project-Based Learning. The supervisor's readiness was an Input Dimension in the present study. Regarding the supervisors' knowledge (item L8), the students believed (M=4.07; SD=0.74) that their supervisors were knowledgeable. For item L9, the students agreed (M=4.10; SD=0.87) that the supervisors have done effective supervisory duties. Finally, for item L10, most students strongly believed (M=4.25; SD=0.70) that they and their supervisors determined the objectives which to be achieved in the project. At a 95% confidence level, the margins of error for items L8 through L10 ranged from 0.06 to 0.08.

Table 2 - Input Dimension (The Supervisors' Readiness) of Project-Based Learning Perceived by Students

	Items	M (ME)	SD	Interpretation
L8.	My supervisor has the appropriate technical knowledge about my project.	4.07 (0.06)	0.74	Agree
L9.	My supervisor has supervised me effectively.	4.10 (0.08)	0.87	Agree
L10.	My supervisor and I have determined the objectives to be achieved in the project.	4.25 (0.06)	0.70	Strongly Agree
	Total average	**4.14**	**0.77**	

Note: In parenthesis is the margin of error at 95 % confidence level

As depicted in Table 3, the means, margins of error, and standard deviations for items S1 to S7 were displayed to answer Research Question 1 from the supervisors' perspective. Regarding item S1, the supervisors strongly agreed (M=4.58; SD=0.54) that the Project-Based Learning approach is appropriate for project course J5012. The supervisor also strongly agreed (M=4.49; SD=0.50) that they could supervise the project effectively with the Project-Based Learning approach (item S2). Regarding item S3, the supervisor believed (M=4.23; SD=0.64) that the project management module was appropriate for the students. Concerning students' project activity, the supervisor strongly believed (item S4, M=4.33; SD=0.52) that student's project activity was based on the module and they also claimed that module content was easy to understand (item S5, M=4.42; SD=0.54). In terms of item S6, the supervisors strongly agreed (M=4.42; SD=0.58) that the weekly goal setting in the module has helped their students to focus on what to be accomplished in the project. Finally, the respondents were strongly believed (M=4.35; SD=0.57) that the module was designed based on Project-Based Learning approach (item S7).

Table 3 - Input Dimension (The Module) of Project-Based Learning Perceived by The Supervisors (n = 43)

	Items	M (ME)	SD	Interpretation
S1.	In my opinion, Project-Based Learning was suitable for final-year project course J5012.	4.58 (0.08)	0.54	Strongly Agree
S2.	With Project-Based Learning, I could supervise the project effectively.	4.49 (0.07)	0.50	Strongly Agree
S3.	Project management module was appropriate designed for the students.	4.23 (0.09)	0.64	Strongly Agree
S4.	Students' project activity was based on the project module.	4.33 (0.08)	0.52	Strongly Agree
S5.	Project management module content was easy to understand.	4.42 (0.08)	0.54	Strongly Agree
S6.	Weekly goal setting has helped my students to focus on what to be accomplished.	4.42 (0.08)	0.58	Strongly Agree
S7.	Project management module was designed based on Project-Based Learning approach.	4.35 (0.08)	0.57	Strongly Agree
	Total average	**4.40**	**0.55**	

Note: In parenthesis is the margin of error at 95 % confidence level

Input dimension in terms of supervisors' technical knowledge and supervisory skills (items S8 through S10)in Table 4 was tabulated. Regarding the supervisors' technical knowledge (item S8), the supervisors strongly agreed (M=4.21; SD=0.63) that their knowledge was appropriate with the students' project. For item S9, the supervisors strongly believed (M=4.28; SD=0.59) that they implemented supervisory duties effectively. Finally, the supervisors strongly agreed (M=4.44; SD=0.54) that the students determine their project goal with their supervisor. The relatively small standard deviation (itemsS8-S10) for the supervisors indicated a high consensus among the respondents.

Table 4 - Input Dimension (The Supervisors' Readiness) of Project-Based Learning as Perceived by The Supervisors (n = 43)

	Items	M (ME)	SD	Interpretation
S8.	I have the appropriate technical knowledge with project title.	4.21 (0.09)	0.63	Strongly Agree
S9.	I implement supervisory duties effectively.	4.28 (0.09)	0.59	Strongly Agree
S10.	My students and I determined the project goals to be achieved in the project.	4.44 (0.08)	0.54	Strongly Agree
	Total average	**4.31**	**0.58**	

Note: In parenthesis is the margin of error at 95% confidence level

Table 1 and Table 2 show the margin of error for the students' data were found lower than the margins error of the supervisors' data at the 95% confidence level (see Table 3 and Table 4). One possible explanation is that the student sample size was larger (n=118) than the supervisor sample size (n=43). The margin of error of a confidence interval tends to increase when the sample size decreases and the standard deviation increases. The total means for the input dimension in terms of the Project-Based Learning module, the supervisors' mean (M=4.40; SD=0.55) is higher than the students' mean (M=3.75; SD=0.83). This could implicate that the supervisors have a more favorable attitude towards the module than their students. Regarding supervisors' readiness, the total mean for the supervisors (M=4.31; SD=0.58) is higher than the students (M=4.14; SD=0.77). This could conclude the supervisors believed that they had a higher level of readiness than it was perceived by their students.

To examine the differences between the students and the supervisors' data, the null hypothesis one (Ho1) was formulated. The independent samples t-test was carried out to determine whether there was a significant difference between the two mean scores. The result showed that t (159) = -5.52, p = 0.00, the p-value was smaller than 0.05. Thus, the Ho1 was rejected (see Table 5).

Table 5 - Independent T-Test for Input Dimension of The Students' and The Supervisors' Perspectives

Input Dimension	n	Mean	SD
Students	118	3.86	0.81
Supervisors	43	4.37	0.56

	Levene' test					T-test for Equality of Means 95% CI			
Variance	F	Sig.	t-value	df	Sig. (2-tailed)	Mean Diff.	SE Diff.	Lower	Upper
Equal	4.84	0.02*	-5.52	159	0.00	-5.06	0.91	-6.87	-3.25
Unequal			-6.65	112	0.00	-5.06	0.76	-6.57	-3.55

*Significance at $p<0.05$

For the Input Dimension, the overall mean for the students was 3.86 and the mean for the supervisors was 4.37. The difference between these two groups was significant at 0.05 α-level. It concluded that supervisors' mean is higher than students'. Thus, it indicated that the supervisors perceived better than the students regarding the items in the Input Dimension. Finding an idea or title of the project was the first main step in the project. Table 6 addresses the students' perception including the means, margins of error and standard deviation. Regarding finding the project's idea, the students agreed (M=3.92; SD=0.79) that they had acquired the idea before the project began (item L11). The students also agreed (M=3.92; SD=0.85) that they were encouraged by the supervisors to find the real problem in the industry (item L12). Nevertheless, the students seemed uncertain (M=3.48; SD=0.93) to find the idea at the library (item L13). Thus, the students seemed to agree (M=3.87; SD=0.94) that they decided idea by themselves (item L14). However, the standard deviations for item L13 andL14 were relatively high suggested a high variation in responses. Finally, the students strongly agreed (M=4.26; SD=0.77) that they discussed project ideas with the supervisor before the project begins (item L15).

Table 6 - Finding Project Idea Perceived by The Students (n = 118)

	Items	M (ME)	SD	Interpretation
L11.	I have the idea about the project before project begins.	3.92 (0.07)	0.79	Agree
L12.	I was encouraged to assess the real problem in the industry by my supervisor.	3.92 (0.08)	0.85	Agree
L13.	I went to the library or information centre to find ideas for my project.	3.48 (0.08)	0.93	Uncertain
L14.	I decided the idea for the project by myself	3.87 (0.08)	0.94	Agree
L15.	I discussed project idea with my supervisor before project begins.	4.26 (0.07)	0.77	Strongly Agree
	Total average	**3.89**	**0.85**	

Note: In parenthesis is the margin of error at 95% confidence level

Finding the idea for the students' project was relatively problematic. Even though supervisors were strongly agreed (M=4.33; SD=0.60) that they encouraged their students to assess the real problem in the industry (item S11) but the supervisors just slightly agreed (M=3.51; SD=0.76) that the students went to the library to find an idea about the project (item S12). About creativity, the supervisors seemed to agree (M=3.65; SD=0.72) that the students were creative in finding the idea for a project (item S13). In terms of mentoring, the supervisors strongly agreed (M=4.23; SD=0.89) that the students discussed the project idea with their supervisor (item S14). However, the standard deviation for item S14 was relatively high which suggested a high variation in responses among the supervisors for the item.

Table 7 - Finding Project Idea Perceived by The Supervisors (n = 43)

	Items	M (ME)	SD	Interpretation
S11.	I encouraged my students to assess the real problem in industry.	4.33 (0.09)	0.60	Strongly Agree
S12.	I found the students go to the library or information centre to get the ideas about project.	3.51 (0.11)	0.76	Agree
S13.	I get my students are creative in finding ideas for their project.	3.65 (0.11)	0.72	Agree
S14.	My students discuss their project idea with me.	4.23 (0.13)	0.89	Strongly Agree
	Total average	**3.93**	**0.74**	

Note: In parenthesis is the margin of error at 95% confidence level

The margins of error for items L11 through L15 for the students ranged from 0.07 to 0.08 and the margin of error for items S11 through S14 for supervisors ranged from 0.09 to 0.13. The relatively high margins of errors for the supervisors may be due to the small sample size of the supervisors. Solving a problem is a complex endeavor that requires an analysis of the problem and finding a solution. Table 8 illustrates their problem-solving skills as perceived by the students. Items L16-L21 were designed to identify the students' problem-solving skills. Asked about their problem-solving skills, the students seemed to agree (M=3.75; SD=0.94) that student's problem-solving skills have increased through Project-Based Learning (item L16). They believed (M=4.09; SD=0.73)that they have discussed their project (item L17). Besides that, the students strongly agreed (M=4.25; SD=0.63) that their critical and creative thinking were needed in solving the problem (item L18). The students believed (M=3.90; SD=0.98) that doing Project-Based Learning with e-SOLMS has increased their ability to work in a group to solve the problem (item L19). They strongly agreed (M=4.30; SD=0.73) that they shared ideas on the project with their groups (item L20). In terms of information management, the respondents concurred highly (M=4.20; SD=0.89) that they managed effectively the information with the group in solving the problem (item L21). However, the standard deviations were relatively high for items L16, L19, and L21 which suggested a lack of agreement.

Table 8 - Problem-Solving Skills Perceived by The Students (n = 118)

	Items	M (ME)	SD	Interpretation
L16.	Through Project-Based Learning, my problem solving skills has increased.	3.75 (0.08)	0.94	Agree
L17.	While there are problems during in the project, I discuss with my supervisor.	4.09 (0.06)	0.72	Agree
L18.	In my opinion, critical and creative thinking are needed to solve the problem.	4.25 (0.05)	0.63	Strongly Agree
L19.	Project-Based Learning has increased my ability to work in group in solving the problem.	3.90 (0.09)	0.98	Agree
L20.	Together with the group, I share my idea with the group in the project.	4.30 (0.06)	0.73	Strongly Agree
L21.	With my group, I manage the information that we get during the project.	4.20 (0.08)	0.89	Agree
	Total average	**4.08**	**0.81**	

Note: In parenthesis is the margin of error at 95% confidence level

Besides the students, the supervisors believed (M=3.86; SD=0.77) that through Project-Based Learning via e-SOLMS, student's problem-solving skill has enhanced (Table 9, item S15). The supervisors also agreed (M=4.09; SD=0.86) that the students discussed with them if there were problems in the project (item S16). As expected, the supervisors strongly agreed (M=4.47; SD=0.59) that critical and creative thinking was needed in solving the problem (item S17). The standard deviation for item S17 was relatively small indicated strong agreement among the supervisors. The supervisors tended to agree (M=4.00; SD=0.81) that Project-Based Learning via e-SOLMS has increased their students' ability to work in a group in solving the problem (item S18) and they also found (M=4.14; SD=0.67) that the students shared the idea with their group during the project (item S19). The supervisors also believed (M=4.16; SD=0.65) that the student has managed information that they get in the project with their group (item S20). High standard deviations for items S16 and S18 suggested a relatively large variability of responses (see Table 9).

Table 9 - Problem-Solving Skills Perceived by The Supervisors (n = 43)

	Items	M (ME)	SD	Interpretation
S15.	Through Project-Based Learning: e-SOLMS, student's problem solving skill has increased.	3.86 (0.11)	0.77	Agree
S16.	Student discussed with me when there is a problem during the project.	4.09 (0.13)	0.86	Agree
S17.	In my opinion, critical and creative thinking are needed in solving the problem.	4.47 (0.09)	0.59	Strongly Agree
S18.	Project-Based Learning: e-SOLMS has increased student's ability to work with the group in solving the problem.	4.00 (0.12)	0.81	Agree
S19.	I found student with their group share idea in the project.	4.14 (0.10)	0.67	Agree

Table 9 – (Continue)

	Items	M (ME)	SD	Interpretation
S20.	I found student with group managed information which they have during the project.	4.16 (0.09)	0.65	Agree
	Total average	**4.12**	**0.72**	

For items L16 through L21, the margin of errors ranged from 0.05 to 0.09 (see Table 8) and the margins of error for items S15 through S20 for the supervisors were ranged from 0.09 to 0.13 (see Table 9). In sum, the total means for the students (M=4.08; SD=0.81) and the supervisors (M=4.12; SD=0.72) were relatively high. It could be said that

Project-Based Learning has enhanced the students' problem-solving skills. Table 10 shows the means, margins of error, and standard deviations for items L22 through L24. These items were designed to measure the students' perspective on time and facility of the Project-Based Learning. Regarding item L22, the students were uncertain (M=3.39; SD=1.15) whether the time allocated was sufficient to complete the project. Nevertheless, they strongly agreed (M=4.22; SD=0.66) that they listed the material, tools, and machines that were needed in the project (item L23). Nevertheless, the students were only slightly agreed (M=3.45; SD=1.23) that machine and equipment at the polytechnic workshop room were appropriate with the project (item L24).

Table 10 - Time and Facility Perceived by The Students (n = 118)

	Items	M (ME)	SD	Interpretation
L22.	I think the time was sufficient to complete the project.	3.39 (0.10)	1.15	Uncertain
L23.	I listed the materials, tools, and machines that were needed in the project.	4.22 (0.06)	0.66	Strongly Agree
L24.	The machines and equipment at the polytechnic workshop room were appropriate for this project.	3.45 (0.11)	1.23	Agree
	Total average	**3.68**	**1.01**	

Note: In parenthesis is the margin of error at 95% confidence level

In terms of duration and facilities (see Table 11), the supervisors agreed (M=3.91; SD=0.78) that the time allocated to complete the project was sufficient (item S21). They also agreed (M=3.74; SD=0.84) that their students have listed all material, equipment, and machines needed for the project (item S22). For item S23, the supervisors believed (M=3.84; SD=0.84) that machines and equipment at the polytechnic workshop room were appropriate to project. The relatively large standard deviations and margins of errors for items S21 through S23 indicated a lack of agreement among the supervisors.

Table 11 - Time and Facility Perceived by The Supervisors (n = 43)

	Items	M (ME)	SD	Interpretation
S21.	I think the time to complete the project was sufficient.	3.91 (0.11)	0.78	Agree
S22.	My students listed the materials, tools, and machines that were needed in the project.	3.74 (0.12)	0.84	Agree
S23.	The machines and equipment at the polytechnic workshop room were appropriate for project.	3.84 (0.12)	0.84	Agree
	Total average	**3.83**	**0.82**	

The students' knowledge improvement was found to enhance after embarking on the Project-Based Learning module. Items L25 through L30 were constructed to determine knowledge improvement among the students. Table 12 presents the knowledge improvement from the students' perspective. Item L25 showed that the students agreed (M=3.97; SD=1.05) that their supervisors assigned the responsibility of project design to them. They also agreed (M=3.67; SD=0.97) that Project-Based Learning by the e-SOLMS approach has improved their self-confidence and motivation (item L26). Regarding items L27 and L28, the students agreed (M=3.69; SD=1.03) that Project-Based Learning has improved their experience related to the project and their knowledge about the project (M=3.86; SD=1.00). Besides, the students believed (M=3.91; SD=0.98) that through the Project-Based Learning approach, they could apply the knowledge gained from the project to meet future challenges. Finally, the students agreed (M=3.87; SD=1.04) that the supervisors have helped them with the theoretical and technical aspects that were needed in the project (item L30). The standard deviations for items L25 through L30 were relatively high that indicated polarized responses.

Table 12 - Knowledge Improvement Perceived by The Students (n = 118)

	Items	M (ME)	SD	Interpretation
L25.	My supervisor assigned the responsibility of project design to me and our group.	3.97 (0.09)	1.05	Agree
L26.	Doing a project through Project-Based Learning by e-SOLMS has improved my self-confidence and motivation.	3.67 (0.09)	0.97	Agree
L27.	I believe my experience has improved during Project-Based Learning.	3.69 (0.09)	1.03	Agree

	Items	M(ME)	SD	Interpretation
L28.	Project-Based Learning has improved my knowledge about the project.	3.86 (0.09)	1.00	Agree
L29.	Through Project-Based Learning, I believed I could apply knowledge gained from the project to meet the future challenges.	3.91 (0.09)	0.98	Agree
L30.	My supervisor helped with theoretical and technical aspects that were needed in the project.	3.87 (0.09)	1.04	Agree
	Total average	**3.82**	**1.01**	

Note: In parenthesis is the margin of error at 95 % confidence level

In addition to the student's perspective, the supervisors were uncertain (M=3.05; SD=1.21) whether they assigned the responsibility of the project to the students. However, the supervisors agreed (M=4.02; SD=0.70) that Project-Based Learning has improved their students' self-confidence and motivation (item S25). They also believed (M=4.12; SD=0.62) that the student gained valuable experience by working in the project (item S26). For item S27, the supervisors strongly agreed (M=4.53; SD=0.50) that e-SOLMS has helped them in assessing the project. The supervisors also concurred (M=4.09; SD=0.68) that through Project-Based Learning, their students could apply the knowledge and experience gained from the project to meet the challenges of work (item S28). Thus, the supervisors strongly agreed (M=4.14; SD=0.60) that Project-Based Learning has improved their students' knowledge about their project (item S29). Regarding the theoretical and technical help, the supervisors agreed (M=4.35; SD=0.61) that they have helped the students in those aspects (item S30). The standard deviations for item S24 were relatively high that indicated a high variation of responses among the respondents.

Table 13 - Knowledge Improvement Perceived by The Supervisors (n = 43)

	Items	M (ME)	SD	Interpretation
S24.	I assigned responsibility of project design to the students.	3.05 (0.18)	1.21	Uncertain
S25.	Doing a project through Project-Based Learning: e-SOLMS has improved student's self-confidence and motivation.	4.02 (0.10)	0.70	Agree
S26.	I believe my students' experience has improved during Project-Based Learning	4.12 (0.09)	0.62	Agree
S27.	Medium e-SOLMS has helped me in assessing the project work.	4.53 (0.07)	0.50	Strongly Agree
S28.	Through Project-Based Learning, I believed the students could apply knowledge gained from the project to meet their future challenges.	4.09 (0.10)	0.68	Agree
S29.	Project-Based Learning has improved my students' knowledge about their project.	4.14 (0.09)	0.60	Agree
S30.	I helped the students with theoretical and technical aspects that are needed in the project.	4.35 (0.09)	0.61	Strongly Agree
	Total average	**4.04**	**0.70**	

Note: In parenthesis is the margin of error at 95% confidence level

Next, null hypothesis two (Ho2) was tested by using the independent sample t-test. The independent samples t-test was applied to determine whether there was a significant difference between the two mean scores. The results show that there was no significant difference between the mean scores of students and supervisors regarding the process dimension, [t (159) = -1.27; p = 0.20], the p-value was greater than 0.05, thus the Ho2 was failed to reject (see Table 14). The mean score of Process Dimension for the students was 3.89 and for the supervisors was 4.01. The difference between these two groups was not significant at the 0.05 α-level. Thus, this concludes that the supervisors did not perceive better than the students regarding the items in the Process Dimension.

Finally, product dimension was formulated to assess the student's and the supervisors' perceptions of the students' final products. Table 15 shows the product dimension of Project-Based Learning which includes the means, the margins of error, and the standard deviations. For item P1, both of the students (M=4.07; SD=1.00) and the supervisors (M=4.12; SD=0.66) agreed that the products were beneficial. In terms of value-added (item P2), the students only agreed (M=3.96; SD=0.92) but the supervisors strongly agreed (M=4.21; SD=0.46) that product has added value. Concerning quality design (item P3a), both the students (M=3.92; SD=0.95) and the supervisors (M=4.12; SD=0.49) agreed that the product has an attractive design. For item P3b, both of the students (M=3.91; SD=0.97) and the supervisors (M=3.79; SD=0.88) seemed to agree that the product has appropriate color. In item P3c, the students (M=3.99; SD=1.00) and the supervisors (M=4.00; SD=0.65) believed that the product has good finishing. Regarding products' function (item P3d), both the students (M=4.13; SD=0.85) and the supervisors (M=4.12; SD=0.49) agreed that the product was easy to use. In the same taken, (item P3e), the students (M=3.92; SD=0.93) and the supervisors

(M=4.05; SD=0.78) agreed that the product has aesthetic value. In terms of commercial value (item P3f), the students (M=4.03; SD=0.88) and the supervisors (M=4.09; SD=0.68) concurred that the product has a commercial value. Finally, for P4, the students strongly agreed (M=4.20; SD=1.00) that they were satisfied with the product. However, the supervisors just agreed (M=4.07; SD=0.45) that they liked the product.

Table 14 - Independent T-Test for The Process Dimension of The Students' and The Supervisors' Perspectives

Process Dimension	n	Mean	SD
Students	118	3.89	0.91
Supervisors	43	4.01	0.73

	Levene' test					T-test for Equality of Means 95% CI			
Variance	F	Sig.	t-value	df	Sig. (2-tailed)	Mean Diff.	SE Diff.	Lower	Upper
Equal	1.62	0.20	-1.27	159	0.20	-2.23	1.75	-5.69	1.22
Unequal			-1.41	92	0.16	-2.23	1.58	-5.37	0.91

*Significance at p<0.05

Table 15 - Product dimension of Project-Based Learning perceived by the students and the supervisors

	Item	The students (n = 118)			Supervisor (n = 43)		
		M (ME)	SD	Interpre -tation	M (ME)	SD	Interpre -tation
P1.	The product are beneficial.	4.07 (0.09)	1.00	Agree	4.12 (0.10)	0.66	Agree
P2.	The product has value-added.	3.96 (0.08)	0.92	Agree	4.21 (0.07)	0.46	Strong Agree
P3a	The product has a beautiful design.	3.92 (0.08)	0.95	Agree	4.12 (0.07)	0.49	Agree
P3b	The product has appropriate color.	3.91 (0.09)	0.97	Agree	3.79 (0.13)	0.88	Agree
P3c	The product has a nice finishing.	3.99 (0.09)	1.00	Agree	4.00 (0.10)	0.65	Agree
P3d	The product is expressive and easy to use.	4.13 (0.07)	0.85	Agree	4.12 (0.07)	0.49	Agree
P3e	The product has aesthetic value.	3.92 (0.08)	0.93	Agree	4.05 (0.12)	0.78	Agree
P3f	The product has commercial value.	4.03 (0.08)	0.88	Agree	4.09 (0.10)	0.68	Agree
P4.	I am satisfied with the product.	4.20 (0.09)	1.00	Agree	4.07 (0.07)	0.45	Agree
	Total Average	**3.53**	**0.49**		**3.59**	**0.10**	

Note: In parenthesis is the margin of error at 95% confidence level

For certain items, the dispersion of the students' answer was strong, indicated that the responses were polarized and varied. However, the standard deviation for the supervisors' items was relatively small, indicated strong agreement among the supervisors. The margins of error for items P1 through P4 ranged from 0.07 to 0.09 for the students and 0.07 to 0.13 for the supervisors at the 95% confidence level. Overall, both students (M=3.53; SD=0.49) and supervisors (M=3.59; SD=0.10) agreed regarding the Product Dimension. The Null Hypothesis three (Ho3) states that there is no significant difference regarding the product dimension between the students and the supervisors. To test the null hypothesis three (Ho3), the independent samples t-test was conducted. The result shows that there was no significant difference between the mean scores of the students and the supervisors, t (159) = -0.82, p = 0.40, the p-value was greater than 0.05, thus the Ho3 was failed to reject (see Table 16).

Next, the Likert-scale questionnaire consisted of the three open-ended items (in part E of the questionnaires). This section focused on identifying the supportive, barriers and recommendations regarding Project-Based Learning. Three open-ended items were posed to the students and supervisors, focused on evaluating the effectiveness of Project-Based Learning. In the beginning, the first open-ended item E1 asked the respondents to list the three most important factors that they believe would help them in the project. As illustrated in Table 17, the students cited the supervisor's support as the most supportive factor that helped them in the project while supervisors identified student's cooperation as the most important factor. The second most frequently cited by the students were the students' collaboration with the team while the supervisors identified their knowledge and skills as the second most important factor. For the third factor, the students have identified the friends' support as a critical factor. Other factors perceived by the students included self-motivation, adequate funding, support from parents, e-SOLMS, adequate time and clear objectives. The supervisors also identified other factors included e-SOLMS, adequate facilities, clear goals and objectives, adequate time, and the module.

Table 16 - Independent T-Test for Product Dimension of The Students' and The Supervisors' Perspectives

Product Dimension	n	Mean	SD
Students	118	3.53	0.49
Supervisors	43	3.59	0.10

	Levene' test					T-test for Equality of Means 95% CI			
Variance	F	Sig.	t-value	df	Sig. (2-tailed)	Mean Diff.	SE Diff.	Lower	Upper
Equal	2.69	0.10	-0.82	159	0.40	-0.06	0.07	-0.21	0.08
Unequal			-1.31	141	0.19	-0.06	0.04	-0.15	0.03

*Significance at $p<0.05$

Table 17 - Supportive Factors in The Project-Based Learning

	The students (n = 118)		The supervisors (n = 43)	
Rank	Factor	Frequency	Factor	Frequency
1	Supervisor's support.	73	Students' collaboration with team and supervisors.	17
2	Student' collaboration with team and supervisors.	57	Supervisor's knowledge and skills.	16
3	Support from friends.	34	Student's behaviors.	14

The second open-ended item (E2) was designed to obtain input from the respondents regarding the most important barriers that they believe impeded effort to complete the project. As shown in Table 18, the students rated inadequate facilities as the most important barrier while the supervisors identified the students' negative behavior as the most important barrier in the project. Interestingly, both the students and the supervisors viewed the inadequate time and inadequate funding as the second and the third important barriers. Other barriers perceived by the students included lack of idea, negative behaviors, and poor supervision. The supervisors cited weakness in students' writing and passivity of the students as the other critical suppressive factors.

Table 18 - The Barriers Impeded Effort in Project-Based Learning

	The students (n = 118)		The supervisor (n = 43)	
Rank	Factor	Frequency	Factor	Frequency
1	Inadequate facilities, machines, equipments.	72	Student's negative behavior (lack of self disciplines, lazy, not committed).	18
2	Inadequate time.	65	Inadequate facilities, machines, equipments, books.	15
3	Inadequate funding.	62	Inadequate time.	14

Finally, the open-ended item E3 asked the respondents to list three suggestions that should be considered in Project-Based Learning. Table 19 presents the suggestions perceived by the students and the supervisors. Interestingly, both the students and the supervisors suggested wider exposure of Project-Based Learning and e-SOLMS to the students. Both groups of respondents also suggested that e-SOLMS should be updated regularly. Finally, the students proposed that the polytechnic provides adequate internet access, especially during the project while the supervisors believed that the students' writing skills should be enhanced.

Table 19 - Recommendations for Project-Based Learning

	The students (n = 118)		**The supervisor (n = 43)**	
Rank	Factor	Frequency	Factor	Frequency
1	Provide exposure about Project-Based Learning and e-SOLMS.	21	Provide exposure about Project-Based Learning and e-SOLMS.	7
2	Updates e-SOLMS.	20	Updates e-SOLMS .	7
3	Provide adequate internet access.	10	Enhance students writing skill.	2

7. Discussion and Implications

Previous studies found that Project-Based Learning is critical to enhancing the students' problem-solving skills. Md. Baharuddin et al., (2009) and Khairul (2010) asserted that the function of the Project-Based Learning module was to enable students to plan their projects, work collaboratively with peers or lecturers. However, in the present study, some students faced difficulty in understanding the project's module. This result was different from Md. Baharuddin and Sharifah (2008) study, that their students found the project module was easy to understand. Regarding the supervisor's readiness, both of the students and the supervisors believed that the supervisors have done their supervisory duties effectively. Besides, students agreed that their supervisors have appropriate technical skills. Nevertheless, few supervisors, especially the new ones have never experienced Project-Based Learning, and thus, they needed to be formally trained to handle it. Also, the empirical data show that the students have selected the project idea by discussing it with their supervisors. The students also agreed that their supervisors have encouraged them to identify the real problem in the industry. So that they have a genuine problem to solve. Nevertheless, the students admitted that they did not fully utilised the library to find the project's idea. Moreover, they depended on the advice and suggestions from their supervisors. The supervisors preferred an innovative and cost-efficient project. Mergondoller and Thomas (2000) asserted that the purpose of Project-Based Learning is to shift the responsibility from the teacher to the students. The students should make a decision for themselves about the project.

To solve the problem, the study found that both the students and the supervisors believe that critical and creative thinking is needed. Further, they seemed to agree that students' problem-solving skills have improved through Project-Based Learning. This result is similar to Jusoff et al. (2010) that found students have developed their critical skills through Project-Based Learning, such as problem-solving, critical thinking, communication, time management, and teamwork skills. The present study found that the students discussed with their supervisors if there were problems in their project. Based on the empirical data, there were several main challenges in completing the project such as insufficient time, high project-cost, and lack of collaboration in the group. Kurzel and Rath (2007) stated that effective teamwork is critical in any project. In terms of project duration and facilities, some students claimed that the time to complete the project was insufficient and some materials for the project were not provided. Blumenfeld et al. (1991) asserted that a project could take a sizable amount of time to be completed. In the present study, the supervisors believed that time for the project is adequate but the students stated otherwise. Concerning knowledge improvement, the respondents agreed that the students have enhanced their knowledge after completing the project. The respondents also believed that Project-Based Learning has improved the students' motivation and knowledge. During the project, the students have learned new knowledge and skills. Only a few students claimed that they did not get any improvement, thus the supervisors believed that these students had less motivation in the project. Similar to the finding of Santana, Dias, Molinaro, and Abdalla Jr. (2010), that the students' involvement in the project with a Project-Based Learning approach has contributed to understanding the real and practical of engineering. Furthermore, the supervisors believed that the e-SOLMS assisted them in monitoring the project. The respondents also concurred that e-SOLMS has helped the supervisors to monitor the progress of the students' project. Both the students and the supervisors believed that most products derived from the projects were usable. However, the supervisors preferred products that were innovative and have value-added. Few students considered their product as a masterpiece. However, some supervisors were less satisfied with the students' products due to poor quality. The supervisors suspected that the poor quality of the product was due to the students' shoddy workmanship.

Based on open-ended items, several supportive and suppressive factors were found that could enhance or impede the Project-Based Learning from the students' and the supervisors' perspectives. The students rated supervisors' support as the most important supportive factor that helped them in completing their project. Next, the students believed a strong collaboration among the team members and support from peers as the second and third important supportive factors. In the same token, the supervisors viewed students' cooperation among the group members and their supervisors, supervisors' knowledge, and students' attitudes as the most important supportive factors in Project-Based Learning. In terms of barriers that hampered their project, the students stated inadequate facilities, time and funding as the main suppressive factors in the project. Schneider (2005) in his research found that students have difficulty in

Project-Based Learning, especially in initiating an inquiry, defining a research project, finding resources, managing complexity of time, collaborating with others, revising the product and following-up the project. The supervisors, however, perceived that the students' negative attitudes, inadequate time and funding as the major barriers in the project.

8. A New Framework Of Project-Based Learning For The Polytechnics

The empirical findings from the present study could suggest several recommendations. One, a new framework for Project-Based Learning could be proposed for the polytechnics system. The study found eight critical elements that facilitate Project-Based Learning in the polytechnics. The eight elements are (1) knowledge about Project-Based Learning, (2) supervision, (3) collaboration, (4) communication, (5) creativity, (6) e-SOLMS, (7) facilities, and (8) accessibility. The first domain is the enhancement of the students' and supervisors' knowledge of Project-Based Learning and the e-SOLMS. The project coordinator should hold briefing sessions with students and supervisors to expose them to the theory and practice of Project-Based Learning before the project begins. Next, the improvement of the supervisors' supervising skills is necessary. It is critical for the institution to train its lecturers to develop both the technical skills and Project-Based Learning supervising skills. Derived from the findings, collaboration plays a key role in completing the project. The fourth element is the communication skills of the students and their supervisors. Weak communication skills were found to be detrimental to the project. During the project, some students had a problem communicating with their supervisors. The fifth element is the students' creativity. The students are expected to have critical thinking and creativity in the project. This can be shown in their final products. The supervisors complained that their students' projects were not innovative. Other important elements are e-SOLMS, facilities, and accessibility.

Based on the empirical data from this study, an alternative framework for Project-Based Learning as shown in Figure 2 was constructed based on the program evaluation. The data confirmed the conceptual framework previously used in the study. The new elements are supervision, collaboration, communication, creative thinking, accessibility, and facility. Thus, the alternative framework for Project-Based Learning is deemed necessary to incorporate the new elements. As the main contribution of this study, the framework (as shown in Fig. 2) is a new addition to the knowledge corpus of Problem-Based Learning for the polytechnic system in Malaysia.

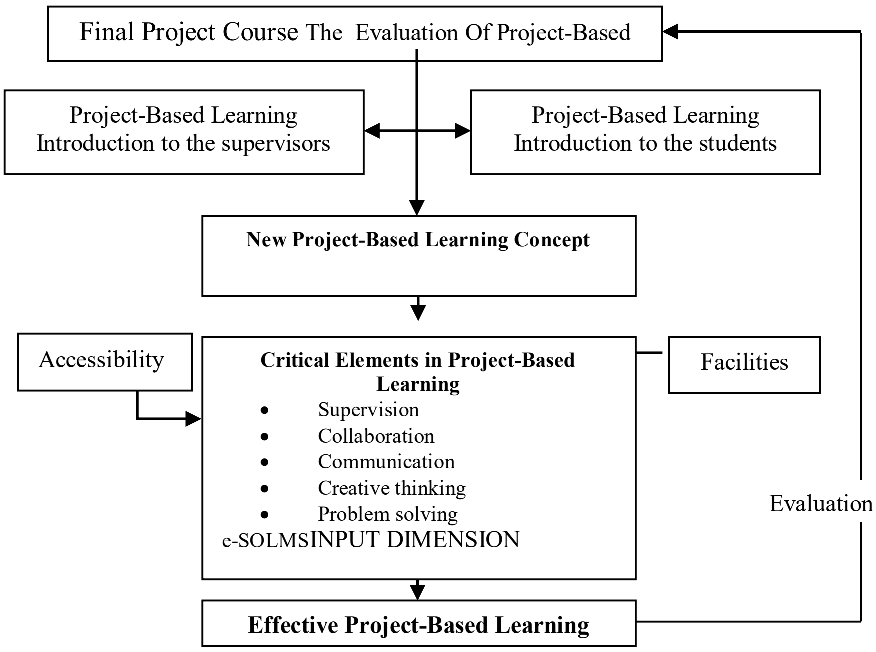

Fig. 2 - A New Framework of Project-Based Learning

9. Conclusion

Based on the empirical data and limitations for the study, several conclusions could be derived. Regarding the input dimension, students perceived the project module has assisted their activities in the project, although some students still faced difficulty in understanding the content of the project module. Hence, the project module needs to be reevaluated. In terms of supervising skills, some supervisors believed their supervising skills are still poor. Therefore, proper training to enhance their supervising skills is deemed necessary. In terms of the process dimension of Project-Based Learning, some students have already had their project ideas since the beginning of their studies at the polytechnic. Thus, in the final semester, they just proposed their ideas to their supervisors to decide on the project's title. However, the students stated they seldom go to the library to search for project ideas. This finding might lead to the conclusion that some students were overly relying on their supervisors' suggestions for the project. The students also stated several suppressive factors in completing the projects such as inadequate time, high project-cost, and lack of communication in the group. The supervisors, however, blamed the problem to the students' negative attitudes, lack of communication, facilities deficiency and lack of creative products. To solve these problems, the supervisors suggested more training to be given to the students in terms of enhancing their communication, critical and creative thinking skills. Finally, in the product dimension, both the students and the supervisors believed the product was beneficial because it has good quality, beautiful design, appropriate color, nice finishing, expressive, easy to use, aesthetic and has commercial value. Nevertheless, some students and their supervisors were less satisfied on the product because the work or idea was not innovative. Besides, based on the main findings of the study, a new framework is proposed which consisted of six key elements: supervision, collaboration, communication, creative thinking, accessibility, and facility. This new framework for Project-Based Learning can contribute to the knowledge pool of Problem-Based Learning for the polytechnic system in Malaysia.

10. Recommendations

This study found that Project-Based Learning has enhanced the students' knowledge and skills in several critical aspects. Therefore, based on empirical data, several recommendations are provided. The polytechnic should continue Project-Based Learning because it is a suitable method for the final project. However, the Project-Based Learning coordinator should seek input and feedback from numerous parties such as experts, lecturers, students, and industry professionals for improvements of the Project-Based Learning module and approach. Paradigm shifts in the mind and attitudes of the polytechnic students are required to alleviate the negativity of the students toward Project-Based Learning. The polytechnics should nurture and incubate the students' higher-order thinking, creativity, and innovative thinking through various programs and training.

In terms of training and facilities, polytechnics should offer a formal course in Project-Based Learning and e-SOLMS for its students. The polytechnic library and resource center should be furnished with relevant and latest books, journals, materials and resources to be used by the students for their project. The polytechnics should obtain new machines, instruments and tools to facilitate the students' project. Moreover, the supervisors and students should be trained on how to run those machines, instruments and tools.

In the context of supervision, polytechnics should train the supervisors to improve their supervising skills. In addition, students' soft-skills such as collaboration, communication, interpersonal, thinking and problem-solving skills should be enhanced with proper training. Finally, the polytechnics should hold various competitions for the students to exhibit and present their products. The best product should be awarded and sent to more prestigious international competitions.

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