Needs analysis on the development of problem based learning module for the microcontroller subject at Vocational College

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Abstract

Based on the analysis of student achievement throughout Vocational Colleges in Malaysia, it was found that the Microcontroller subject had the lowest achievement compared to other subjects. The results of the achievement analysis also show that students have difficulty achieving good results in the subject of Microcontroller. This indicates the need for improved implementation of the Microcontroller teaching and learning system implemented in the classroom. In regard to this matter, this study aims to identify the difficulty level of the six main topics (unit 1 - 6) and sub-topics in ETN5044 as well as the perception of the lecturers and students towards the existing module and the teaching and learning methods of the Microcontroller subject. The findings of this study shall initiate the phase of developing a learning module for the Microcontroller (ETN5044) subject using Problem Based Learning (PBL). The needs analysis also aims to determine whether the product meets the learning needs of the students. An observation was conducted involving 27 lecturers and 322 students who enroll into the 6th semester of the Electronic Technology diploma programme at several Vocational Colleges in Malaysia. The findings show that the majority of lecturers and students regard the sub-topics for topic 2 that is "Applying the instruction set of Microcontrollers" as difficult with average mean values of lecturers being 2.96, 3.07, 3.00 and 3.10, while mean values for students were 2.19, 2.21, 2.16, and 2.30. Their perception also indicates that the PBL module has never been implemented. Such findings support for the development of a learning module particularly for students undertaking the Microcontroller subject.

Keywords: *Problem Based Learning (PBL), Microcontroller, Problem Solving Skills, Sidek's Module Development Model.*

INTRODUCTION

The Technical Vocational Education Training (TVET) in Malaysia has experienced major changes along with the nation's needs in the aspect of economy, politic, social, and technology. The main objective of TVET is to produce highly skilled human capitals as aligned in the Industrial Revolution 4.0 (RMK-11, 2018, MEDP 2015-2025, 2018). Realising the importance of TVET, the government has rebranded TVET as part of the efforts to become a high-income developed country in 2020 (MOE, 2017). Aligned with the need to increase the development of the local human resources, the establishment of TVET institutions such as Vocational Colleges (VC) is essential to achieve the 2020 vision.

The establishment of VC aims to create more opportunities for skill-based trainings as well as to rectify the issue of academic dropout among students. Besides skills, VC also aims to instil the 21st century skills into the process of teaching and learning in the classroom. This shall increase students' marketability in the complex and competitive working environment and subsequently prepares them for the global economic challenges (Faridah et al., 2014). The 21st century skills comprise various elements that are essential in today's technological era, including communication skill, problem solving skill, and interpersonal skill (Ismail 2013, Ainun, Zamri & Wan Muna, 2017) as well as soft skills (Rusmini, 2013). Problem solving is one of the essential skills that should be acquired by students in the 21st century (Siahaan et al., 2018). In addition, changes in industrial demand (MEDP, 2015-2025) as well as the requirements of accreditation criteria require engineers to have solid understanding towards the basic engineering science, possess practical basics and competent problem solving skill, able to work together as a team and demonstrate exceptional communicational skills (Rufaizal & Azuin, 2017; Sepahkar, Hendessi, & Nabiollahi, 2015).

For that matter, the module that employs the Problem Based Learning (PBL) approach was developed for the Microcontroller subject in catering the current learning needs. The PBL approach is selected as its criteria overcome the 21st-century learning. It has the potential to generate a wide and flexible basis of knowledge, effective problem solving skills (Gabb & Vale, 2001), teamwork (Sellnow & Ahlfeldt, 2005), and inner motivation that encourages the learning process (Hmelo-Silver, 2004; Savin-Baden, 2000; Harun, Yusof, Jamaludin, & Hassan, 2012; Pan & Allison, 2010). The PBL approach is also capable of developing students' self-directed learning skills (Barrows, 1986; Norman & Schmidt, 1992; Leary, 2012). Microcontroller is a field that is widely used within the global industry. Multiple technologies have been combined and moulded according to the industrial needs in order to meet the current global market (Yeong et al., 2013). The usage of the Microcontroller technology is rapidly and competitively growing in producing market products that are relevant and profitable to all users. Thus, knowledge on microcontroller should be expanded among students of the Electronic Technology programme at VC. This shall provide them with the opportunity to expand their potential, the ability to rectify issues that require advance problem solving skills, as well as exposing them to the early curriculum on the real application in the engineering world. Competency in the coding language is also necessary in producing coding experts through the Microcontroller subject.

The Microcontroller subject is selected as the focus of this study as it is observed to record the lowest level of achievement on 2015/2016 as compared to other subjects enrolled by semester 5 students at several VC in Malaysia. Table 1 shows the percentage of achievement level recorded by diploma students according to the subjects that they took in semester 5 (*Assessment and Evaluation of Vocational College 2015/2016, MOE 2016)*. Based on Table 1, the level of achievement for Microcontroller has recorded a good level of 30 percent with the score (60-79), the passing level with 60 percent with the score (50-59), and 10 percent of failure with the score (0-49). Meanwhile, no excellent level with the score of (80-100) is recorded. This indicates that Microcontroller is a difficult subject for students to achieve an excellent score. Such data shall be the grounding basis for the researcher to develop a module with supporting materials for the benefit of the students as they attempt the difficult topics in the Microcontroller subject. Figure 1 shows the students' level of achievement.

Table 1. Level of Achievement among Semester 5 Students According to Subjects in 2015/2016

No	Subjects	Level of Achievement (%)			
		Excellent	Good	Pass	Fail
1	ETN 503 & Supervisory Skill	70	25	5	0
2	ETN 5013 Industrial Automation	40	55	5	0
3	ETN 5024 Peralatan Video	20	70	10	0
4	ETN 5044 Microcontroller	0	30	60	10

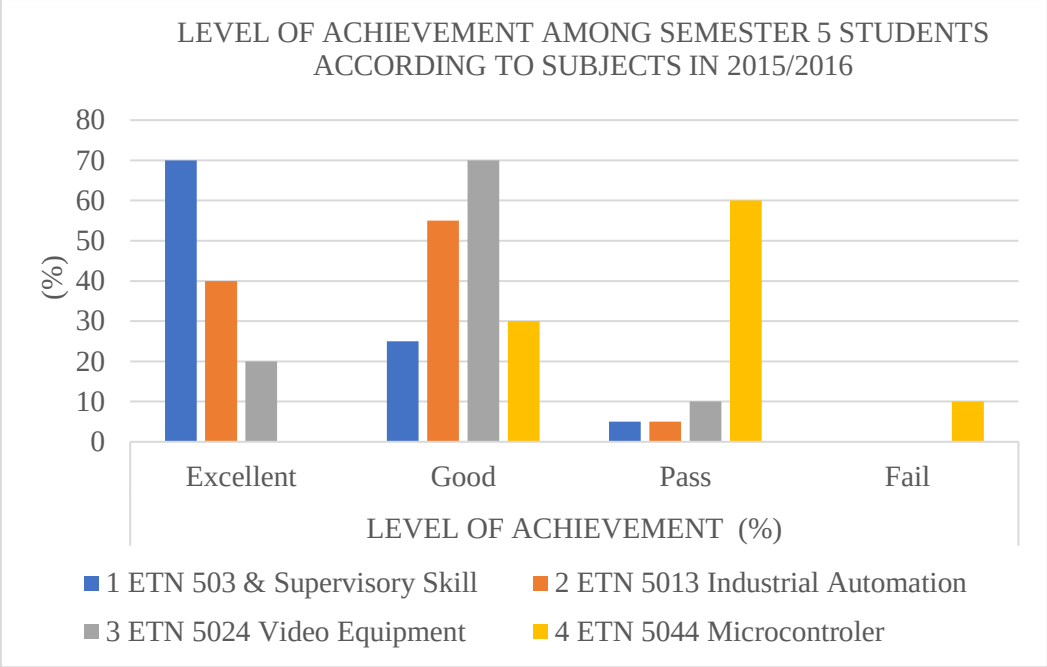

Figure 1. Level of Achievement among Semester 5 Students According to Subjects in 2015/2016

Regarding this matter, this study aims to identify the need to develop a learning module for the Microcontroller subject that employs the Problem Based Learning (PBL) approach from the perception of the lecturers as well as the students. Findings from the needs analysis shall focus on the development of elements in the PBL module. Besides that, needs analysis is the primary step in education planning which identifies the current and targeted situations that are problematic and require contextual and specific solutions (Iwai et.al 1999; McKillip, 1987). It serves the purpose of planning the curriculum in detail, identifies the issues in the target group, and closes the existing gap in the system. This study uses needs analysis to investigate the problems and obtain important information prior to deciding on the structure and development of instructional materials in the following phases such as i) identifying the target or focus group, ii) conducting needs analysis among students and lecturers and, iii) a pilot study was conducted prior to the distribution of questionnaire in this phase. Among the theories involved in this study include the Constructivism Learning Theory, Contextual Learning Theory, Experience Based Learning Theory, Cooperative Learning Theory, and Cognitive Theory: Vygotsky's Zone of Proximal Development, as well as the elements in the learning strategies that are incorporated in the module that will be developed.

Furthermore, module is a comprehensive learning material that allows students to attempt exercises and revision (Sidek & Jamaludin, 2005) and assist in their understanding of a subject without depending on the lecturers (Kamdi, 1990). The process of building a module should focus on various rules and procedures for the benefit of its efficacy. This is because students' adherence to a module shall translate into their success achievement of the specified objectives. Therefore, students' possibility to succeed is dependent on the procedures that should be adhered by module developers (Sidek & Jamaludin, 2005). Figure 2 shows the steps involved in the process of module development as outlined by Sidek's Module Development Model (Sidek & Jamaludin, 2005).

METHODOLOGY

Research Design

The needs analysis involves several observations that evaluates the needs of lecturers and students for the purpose of developing the PBL module. Such analysis is conducted to identify the gap between the current and targeted situation and whether such gap should be treated. The treatment refers to the

process of teaching and learning using the module that incorporates the PBL approach. This study was conducted at several VC in Malaysia until saturated data was obtained. The data collection process involves lecturers who teach the Microcontroller subject and semester 6 diploma students who enrol into the subject. Two different sets of questionnaires were distributed to the respondents and they were allotted with 10 minutes to answer questions related to the level of difficulty of each topic and their perception towards the existing module and teaching and learning approach in Microcontroller. Figure 2 shows the flow chart on the needs analysis.

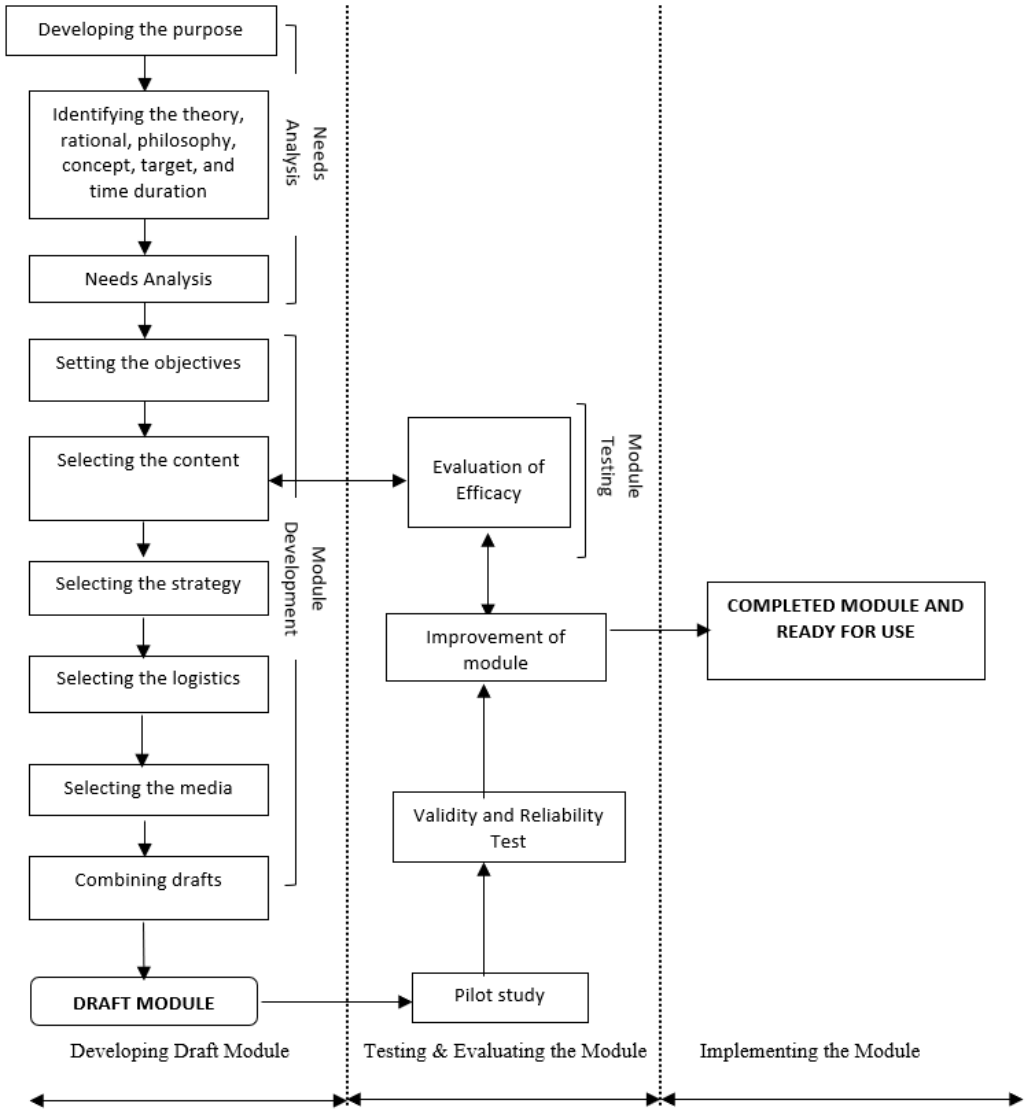

Figure 2. Flow Chart on the Development of the PBL Micro-C PRO Module as Adapted From the Module Development Model Sidek & Jamaludin (2005)

Research Sample

The research sample comprises 27 lecturers of the Microcontroller subject and 322 students from several Vocational Colleges in Malaysia who enrolled in the 6th semester of the Electronic Technology diploma and study the Microcontroller subject. The sample selection process from the population is achieved during cluster sampling. Cluster sampling is a sampling that involves the selection of groups or clusters rather than individuals (Creswell, 2014; Fraenkel, Wallen, & Hyun, 2015). In other words, researchers used existing classes in the population studied. The total population who enrolled in the 6th semester of the Electronic Technology is 1952. According to Krejcie &

Morgan (1970) and Cohen et al. (2001) sample size of 322 is sufficient. Table 2 shows the background information of the lecturers and students according to their ethnicity.

Table 2. Background information of the lecturers and students according to ethnicity

Respondents	**Ethnic**				**Sum**
	Malay	Chinese	India	Other	
Lecturers	22	5	0	0	27
Students	295	19	8	0	322

Research Instrument

The research instrument employed in the needs analysis is a questionnaire on the level of difficulty and a questionnaire that elicits the perception of the lecturers and students towards the existing module and approach in the teaching and learning of the Microcontroller subject. The former was administered to both lecturers and semester 6 diploma students in order to evaluate the difficulty level of all topics in the Standard Curriculum for Vocational Colleges (SCVC) for the Microcontroller subject. Semester 6 students were chosen as they had completed all SCVC in the Microcontroller subject. This questionnaire contains 3 parts. Part A gathers their background information. Meanwhile, Part B comprises a list of difficult topics based on the SCVC where respondents were asked to state their level of agreement using 5-point Likert scale of 1=Strongly disagree, 2= Disagree, 3= More or less agree, 4= Agree and 5=Strongly agree. Finally, Part C uses an evaluating scale of 1=YES and 2=NO where respondents were asked to evaluate whether the existing module has incorporated the PBL approach during the in-class teaching and learning sessions. This questionnaire is adapted from several questionnaires used by previous studies of similar topic (Mohd Paris Saleh & Saedah Siraj, 2016; Hassan & Ab Aziz, 2011). The pilot study shows that the reliability test of alpha Cronbach for the questionnaire on the level of difficulty for lecturers is .89 and .75 for students. Both questionnaires were proofread by subject-matter experts for its accuracy in language, items, and content.

Research Analysis

The data analysis was conducted using descriptive statistics to determine the mean value, standard deviation, and percentage. It is presented using tables for analysis purpose. The difficulty level of the topics was analysed using mean and standard deviation to compare the data gathered from the lecturers and students. Meanwhile, the data pertaining to the perspective of the lecturers and lecturers towards the existing module and approach in the teaching and learning of Microcontroller was analysed using percentage as it involves the evaluating scale of YES/NO.

Findings

The findings obtained through the data analysis procedure highlight on the necessary needs that should be addressed in the development of module. The topics with low mean values are considered as having high difficulty while topics with high mean values are regarded as having low difficulty. The mean values of both lecturers and students are also compared to identify the needs from both perspectives. Table 3 summarises and compares the data from the perspective of both lecturers and students.

The findings in Table 3 show Application of Microcontroller Instruction Set (unit 2) as the topic with the highest level of difficulty in the ETN5044 module. Both lecturers and students share similar perception on the difficulty level of sub-topics in topic 2 (unit 2) where they have recorded the lowest mean value as compared to the sub-topics in other main topics. The mean value for each sub-topic in topic 2 are shown in Table 3 and it comprises the perspective of the lecturers and students.

The data on the lecturers' perception towards the existing module and approach to the teaching and learning of Microcontroller is used to determine whether the existing module incorporates the PBL approach during the teaching and learning process in the classroom. Table 5 summarises the lecturers' responses where the majority of them answered "YES" for item 1 until 4. This indicates their positive perspective on the use of the module as a teaching aid in class.

Meanwhile, item 5 and 6 have the lowest percentage as the majority of the lecturers answered "NO". All lecturers responded "NO" to item 6 "*I use the microcontroller module that incorporates problem based learning according to the difficulty level of each topic*" which subsequently indicates that the lecturers have never used a Microcontroller module which is incorporated with the PBL approach.

Table 3. Responses from the lecturers and students on the difficulty level of the six main units

Sub unit	Item	Level of Difficulty			
		Lecturers		Students	
		Mean	S.D	Mean	S.D
	Unit 1: Classifying the basic construction of microcontroller				
1.1	Identifying basic constructions in microcontroller	3.41	.971	4.56	.666
1.2	Implementing structure of processing memory and its variation	3.37	.926	4.42	.663
1.3	Arranging data memory	3.37	.926	4.30	.803
	Unit 2: Applying instructional set of microcontrollers				
2.1	Defining the basic program of assembly language	2.96	.854	2.19	.880
2.2	Using data and manipulation bit instructions	3.07	.874	2.21	.861
2.3	Validating interrupted control flow	3.00	1.000	2.16	.898
2.4	Validating the interface/intraface of microcontroller	3.19	.962	2.30	.939
	Unit 3: Implementing real time control: interruptions				
3.1	Identifying interruptions on microcontroller operating structure	3.67	.620	4.21	.914
3.2	Checking whether to activate or disable a source	3.59	.694	4.05	.950
	Unit 4: Implementing real time controller: Timer				
4.1	Implementing programmable timer in MCU's	3.52	.893	4.02	.859
4.2	Implementing interrupted intervals and density limit	3.44	.974	3.93	1.121
	Unit 5: Designing digital and analogue interface system				
5.1	Differentiating between switch, keyboard, and keyboard between interface	3.63	.967	4.33	.715
5.2	Implementing numeric/alphabetic devices	3.33	.920	4.74	.581
5.3	Designing programmable interface instruments using IEEE Bus	3.81	.681	4.56	.629
	Implementing the process of industrial control system	3.56	.577	4.35	.720
5.4	Implementing the prototype of instrument-based microcontroller unit	3.59	.747	4.37	.655
	Unit 6: Applying real-time operating system to microguards				
6.1	Implementing real-time operational system	3.63	.688	4.33	.778

Table 5 is the summary on the students' perception towards the existing module and approach in the teaching and learning of Microcontroller. The majority of students demonstrate positive perception on the use of the module as a teaching aid in class. This is evident by the high percentage of students who responded "YES" for item 1 until 5. In this regard, all students responded "YES" for Item 2 which is "*The Microcontroller subject helps me to think in solving problems.*". Meanwhile, item 6 until 8 have the lowest percentage value as the majority of students answered "NO". In this regard, 99.4% students

disagree with item 6 "*Does the microcontroller learning module incorporate problem-based enquiries to begin the learning session?*" which indicates that they have never encountered a Microcontroller module that uses the PBL approach.

Table 4. Summary of questionnaire on the lecturers' perception towards the existing module and approach in the teaching and learning of Microcontroller

No	ITEM	EVALUATING SCALE		Percentage (%)	
		Yes	No	Yes	No
1	I use teaching aids in the teaching and learning of microcontroller.	26	1	96.3	0.3
2	I use teaching aids like the module.	25	2	92.6	0.6
3	I produce microcontroller module every year.	26	1	96.3	0.3
4	I am benefitted from continuous usage of the microcontroller module.	26	1	96.3	0.3
5	The micro controller module that I developed incorporates the problem based learning approach.	2	25	7.4	92.6
6	I use the microcontroller module that incorporates problem based learning approach in all learning content to begin the learning session.	2	25	7.4	92.6
7	I use the microcontroller module that incorporates problem solving learning approach based on the difficulty level of each topic.	0	27	0.0	100.0

Table 5. Summary of questionnaire data on the students' perception towards the existing module and approach in the teaching and learning of Microcontroller.

No	ITEM	EVALUATING SCALE		Percentage (%)	
		Yes	No	Yes	No
1	I am excited to learn the Microcontroller subject.	312	10	96.9	3.1
2	The Microcontroller subject helps me to think to solve problems.	322	0	100.0	0.0
3	The lecturers use teaching aids frequently.	302	20	93.8	6.2
4	I feel happy whenever the lecturers use teaching aids like learning module in their teaching of Microcontroller.	317	5	98.4	1.6
5	The learning content can be easily understood when the lecturers use the module during Microcontroller learning session.	306	16	95.0	5.0
6	Does the microcontroller learning module incorporate problem-based enquiries to begin the learning session?	2	320	0.6	99.4
7	I use the Microcontroller module to do exercises in solving problems with my friends.	5	317	1.6	98.4
8	All content in the Microcontroller module incorporate problem-based learning during the teaching and learning session in the classroom.	4	318	1.2	98.8

DISCUSSION

What is the extent of difficulty for all six main topics and sub-topics in the Microcontroller subject from the perspective of the lecturers and students?

Findings for the first research question indicates that the lecturers and students have similar perception on the difficulty level of the Applying Instructional Set of Microcontroller (unit 2) topic.

The responses in Table 3 show that both lecturers and students perceive the sub-topics in Applying Instructional Set of Microcontroller as the most difficult topic in the ETN5044 module. The students believe that unit 1 is the easiest topic. On the other hand, unit 2 is the hardest topic especially as it has a continuity with the following units. Therefore, their understanding of unit 2 shall affect their understanding to the following units especially unit 3 and 4. According to the lecturers, students are unable to differentiate real-time control as they are unable to identify interruptions. Apart from that, they are also less competent in the assembly where they are more comfortable to use the C language in doing their practical. As a result, they are having problems to complete any given task. Gomes & Mendes (2007) believe that students have less capability to do programming due to their inability to create algorithm, especially due to having limited ability in problem solving. Kalelioğlu & Gülbahar (2014) also found that most lecturers are having the difficulty to guide students to be competent in programming due to their weakness in problem solving skills and critical thinking. Research by Masura Rahmat et al. (2012) has identified several problems faced by students in programming namely resources, lectures and practical approaches, capability in problem solving, time management, and self-confidence. This means that students should possess strong basic knowledge in both theory and practical for them to apply as they do any programming tasks given during the teaching and learning session.

Does the existing module in Vocational Colleges incorporate the PBL approach?

Table 4 and 5 summarise the questionnaire related to the perception on the use of the existing module and approach in the teaching and learning of the Microcontroller subject. The data determines whether the module has incorporated the PBL approach in its implementation. Table 5 and 6 show that the majority of lecturers and students indicate that a module with the PBL approach has never been implemented. Therefore, the researcher aims to develop a PBL-based module as such approach is inclined towards the 21st century learning. Moreover, the PBL approach is capable of promoting the high order thinking skills among students in VC. This is aligned with the needs in the Microcontroller subject that require problem solving skills in solving questions like programming. Previous studies on PBL have focused on improving motivation (Jones et al., 2013; Surif et al., 2013), generic skills (Halizah, 2010; Hande et al., 2015), the obtain of knowledge (El-shaer & Gaber, 2014), critical thinking capability (Janagam, Suresh, & Nagarathinam, 2011; Alias & Sulaiman, 2012; Eman Saleh & Hanan Mohamed, 2013; Yu et al., 2013) and problem solving skills (Nur Izzati et al., 2010; Zulida et al., 2016, Riyati, I, & Suparman, S. 2019) among students. Thus, PBL is the main keyword in improving students' achievement in the Microcontroller subject.

What is the perception of the lecturers and students on the teaching and learning approach in the Microcontroller subject?

The data in Table 4 and 5 also indicate positive responses from the majority of lecturers and students towards the use of the module as an in-class teaching aid. A total of 96.3 percent of lecturers answered "YES" for the item *"I use teaching aids in the teaching and learning of microcontroller."*, "*I produce microcontroller module every year*.", and "*I am benefitted from continuous usage of the microcontroller module.".* On the other hand, 100 percent students answered "YES" for the item *"The Microcontroller subject helps me to think to solve problems."* The item with the second highest percentage is *"I feel happy whenever the lecturers use teaching aids like learning module in their teaching of Microcontroller."* with 98.4% answered "YES". A module eases the cognitive development and in-depth understanding of a particular subject (Riasat, Muhammad, Shukat, & Zakia, 2012), increases achievement (Norlidah et al., 2014), improves motivation (Wingo, Thomas, Thompson, & Cook, 2015), and effectively foster students' interest to learn (Kraus, Sears, & Burke, 2013). In conclusion, module is a medium that delivers a message effectively, a comprehensive teaching aid, negotiates the delivery and perceiving of knowledge, and upholds the element of human capital from the aspect of Attitude, Skills, and Knowledge. This justifies the selection of module as a tool in assisting the process of in-class teaching and learning.

CONCLUSION

The needs analysis reports on the issues and problems pertaining to the teaching and learning of the Applying the Instructional Set of Microcontroller (unit 2) topic at all Vocational Colleges involved. In general, the lecturers and students regard the topic as having the highest difficulty among all topics in the ETN5044 module. As the lecturers and students are inclined to use the module in the teaching and learning of Microcontroller, the researcher shall incorporate the elements of PBL into the existing module in Vocational Colleges. Although students of Vocational Colleges are often misunderstood as having less academic competency, the majority of them are excited to learn the Microcontroller subject. Despite being a tough subject, the students believe that Microcontroller shall help them to think in solving problems systematically. By applying learning theories like the Constructive Learning Theory, Contextual Learning Theory, Experience Based Learning Theory, Cooperative Learning Theory, and Cognitive Theory: Vygotsky's Zone of Proximal Development as well as the PBL elements into the module that will be developed, the researcher hopes to assist students in completing the module. The PBL approach also contains the criteria for 21st century learning that will foster higher order thinking skills among students of Vocational Colleges along with the development of skills in the 21st century skills as well as the needs in the Industrial Revolution 4.0.

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