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MODULE INTERVENTION: EFFECT ON PROBLEM SOLVING SKILLS AMONG TECHNICAL STUDENTS

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***Abstract:** Technology engineering education in Malaysia is constantly changes because of development progress in industry and technology demands. Therefore, a soft skill such as problem-solving skills is crucial for graduates in technical and technology engineering education field. Various initiatives have been implemented in ensuring that they are capable to enhance students' problem-solving skills. These research papers discuss the development of a module to support students' problem-solving skills and also the effectiveness of module implementation. The investigation was based on the previous issues from problem-solving in final year project, written feedback from industries and also by observation during the class. Furthermore, the underpinned theories used for the development module were Theory Inventive Problem Solving and Experiential Learning Theory. An experiment was carried out from one of Majlis Amanah Rakyat Higher Technical Institution in Malaysia. Interventions of the module were implemented during a semester academic week. Two groups were formed: Treatment and Control group. Data were taken before and after module intervention (pre-test and post-test). It represents technical students in the area of diploma engineering technology education. The data was analyzed quantitatively and the results shows students' lack of exposure in problem-solving techniques. It was discovered by many of the students' tend to solve the problem by intuitive rather than a systematic approach.*

***Keywords:** Final Year Project, Technical Institution, Problem Solving Approach, Engineering Technology*

Introduction

Technical and Vocational education introduced in Malaysia education system since 1987 (Rashid & Education, 2011). It started in 1906 when technical school was opened to give technical training for technicians in the government sector and thus give an impact on vocational development. From that, the government has determined vocational education is one of the sectors to drive an economy of Malaysia country by providing skilled manpower to fulfill industries demand (Azman, 2015).

Vocational education is further enhanced by the establishment of a training-based institute and is known as Technical and Vocational Education and Training (TVET). One of MARA TVET institution that provides an employability skill required by industries was Kolej Kemahiran Tinggi MARA (KKTM). However, one of the employability skill that very important and really required by employer was problem solving skills. In any organization or workplace the employer always rely on employees to identify and solve the problem. Since creativity is needed in solving problems, they need to be practiced in a consistent way. Systematic methods that assisted by experiential learning also can achieve the optimal solutions.

Literature Review

TVET was very important in human resource development. By utilizing of TVET role in linking workforce, social and economic development strategies it's able to increase nation ability to be a fully developed nation (Meera, Pradeep, & Sehoon, 2014). A TVET qualification equipped someone or graduate with specific skills required at the workplace. The problems need to be solving faster, accurate, effective and efficient. Therefore, in 21st Century Skills the TVET program promotes a skill such as Problem solving; Science, Technology, Engineering, Mathematics (STEM); and Four 4C: Critical Thoughts, Communication, Collaboration, & Creativity. (Reeve 2016).

However, some observation has been made in TVET institution and also a response from industry, one of the reasons or issues students and graduates that not meet the criteria as a potential worker was they are lack of problem-solving skills (Seman, Rahman, & Ahmad, 2014).This also supported by Chiang (2016), mentioned students had a difficulties in problem solving skills, thus they are not able to produce or complete a task given (Chiang & Lee, 2016).Furthermore a various research studies also had been documented by a researcher that mentioned graduates do not meet industries need. Malaysian students still not achieve the criteria of good workers (MEF 2011) because of lacking in problem solving skills which is a part of employability skills.

Therefore, the development of human capital in Malaysia needs a shifting paradigm which focuses on more producing a quality of graduates so that they can become competitive workers. This is also supported by Jawhara (1995), students need to be exposed by exploring the problem frequently. Apart from that, they can gain experiences in solving a problem by solving open-ended problem-solving activities. Indirectly it can be used to encourage students to become creative and innovative. Therefore, some changes in education should be made to overcome the issues, especially in the teaching and learning system. The new approach needs to be considered such as problem-solving skill, the systematic method, optimizing students experience to reduce conflict, open-ended question and solution so that students can develop their skills as well as become an independent learner.

Research Theories

The underpinning learning theories used in this study were the Experiential Learning Theory (ELT) and the Theory of Inventive Problem Solving (TRIZ). TRIZ was developed by the Russian scientist Genrich Altshuller (1926-1998) in between 1960 and 1980 and this was contrasted with "trial and error" method. TRIZ is a systematic analysis by providing a guideline of the system that can be improved. It provides a systematic procedure for problem solvers to produce good solutions by giving value added (Mann, 2002). The principle used in TRIZ for problem-solving is illustrated in Figure 1.

The first step was a specific problem. Here the problems need to be defined accurately. Next was the TRIZ Generic Problem, and in this step, the type of problem needs to be classified accordingly. TRIZ has a wide array of tools for inventive problem solving by classifying the problem type before select the tools accordingly. Next, apply TRIZ tools to generate potential solutions of the problem. Finally, evaluate the soundness of the new and specific solution. Each stage can be cycled through at different times during the problem-solving process.

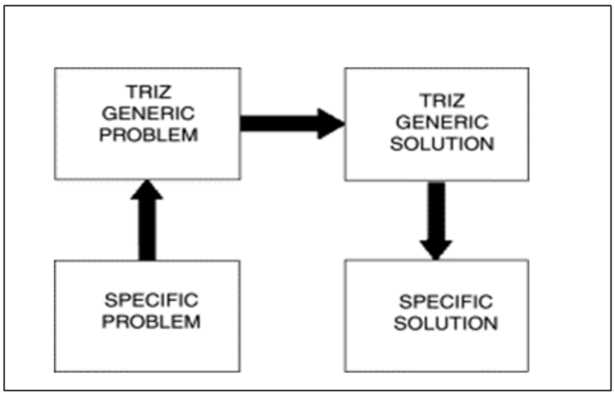

Figure 1: Principle of TRIZ

Experiential education considered as education with direct participation in life (Mi Dahlgaard-Park, 2006). This supported by Anderson et al. (2000) which considered experience is an element of the educational process (Andresen, Boud, & Cohen, 2000). Furthermore, Kolb's defines the Experiential Learning Theory (ELT) as a process whereby knowledge is created through the transformation of experience. Knowledge comes from the combination of grasping and transforming experience (Yardley, Teunissen, & Dornan, 2012). Experiential learning provides students the opportunity to directly apply the information they possess in order to build self-efficacy and learn from the experiential undertakings. Its focus more on the experiential learning process rather than on fixed learning traits (Turesky & Gallagher, 2011), providing for an acknowledgment and incorporation of personal change and development in the model (Healey & Jenkins, 2000). Kolb ELT stressed learner needs to pass through all an experiential learning cycle (ELC) which are concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE). By attempting all the cycles, it can construct individual become effective learners.

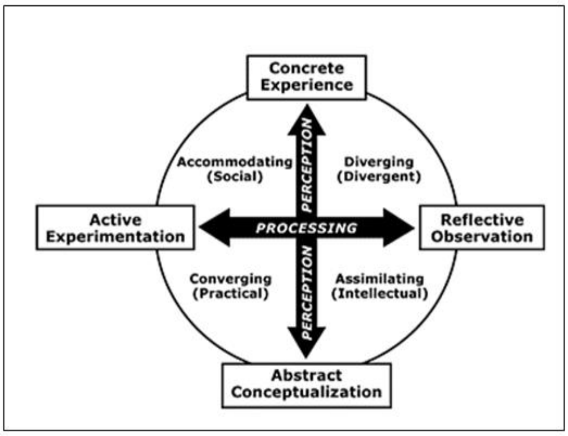

Figure 2: Principle of Kolb Experiential Learning Theory

Research had been identifying that Experiential Learning Cycle is more suitable for engineering education (Abdulwahed & Nagy, 2009). This supported by Stice (1987), that used ELC to improve undergraduate learning process in their class (Stice,1987). The Experiential Learning Cycle (ELC) as shown in Figure 2 begins with the concrete experience that is fundamental for observations and reflections. Then it leads to abstract conceptualization which can create new ideas and thinking. Next, thinking is applied towards active experimentation into new learning in creating new experiences. A learner was allowed to begin at any stage of the cycle and for the stages to be repetitive. Although Kolb's Experiential Learning Cycles has similarities with other active learning approaches but the main differences compared to other active learning approaches are that Kolb's ELC considers experience as the foundation of learning (Conole, Dyke, Oliver, & Seale, 2004).Therefore, this difference is also the main justification and reason for using it as a research theory to design a module.

Research Methodology and Results

The research method consists of 3 phases as shown in Figure 3. Phase 1 as a preliminary study to investigate the student difficulties. Then, the findings in the preliminary study were considered to develop a module in the following phase. Next, a complete designed module in Phase 2 was used for implementing an intervention class and module. Lastly, Phase 3 for result analysis and also findings from the module intervention.

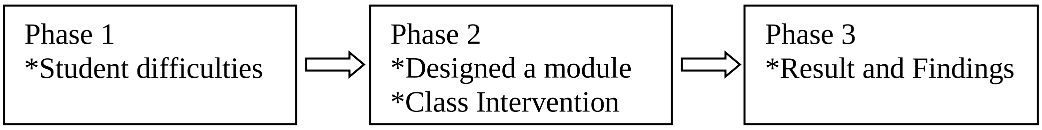

Figure 3: Research Phases

Phase 1

The learning sequence was designed to lead students through the full cycle of experiential learning cycle (ELC) and also Theory of Inventive Problem Solving (TRIZ) step as shown in Figure 4. Each question was designed to suit and covered the cycle for both theories. The stage of ELC was incorporated into TRIZ steps approach and it was starting from cycle 1. Therefore instructors should be able to foster more comprehensive learning that can be gained from a single perspective (Svinicki & Dixon, 1987).

THEORIES	CYCLES			
	1	**2**	**3**	**4**
ELC	Concrete Experience	Reflective Observation	Abstract Conceptualization	Active Experimentation
TRIZ	Specific Problem	Generic Problem	Generic Solution	Specific Solution
No of Question	**Question 1**	**Question 2**	**Question 3**	**Question 4**

Figure 4: A Designed Learning Sequence Mapped

This problem-solving test questionnaire was adapted from the TRIZ Innovation Situation Questionnaires (2010). However, the modification has been made from the original questionnaires when there were not sufficient questions on a particular problem-solving. Each question has the marks. Examples of the questions were shown in Figure 5.

Explain the system function.
Choose the parameter involve in the system.

Figure 5: Example Questions Tested

Question 1 was covered the first cycle in ELC and TRIZ to investigate students' weaknesses in concrete experience and specific problem. Follow by Question 2 in cycle 2 to look into students' skills by generating a similar problem and reflecting their observation. Then, in cycle 3 students need to generate the solution by understanding the concept before they produce a specific solution and experiment in cycle 4.

Four questions were tested into 44 students to investigate their current problem-solving skills. Then, the results findings from this study were used as a guide to developing a real module. Based on the result in Table 1, it can be concluded that students have fewer difficulties in defining the problem where 65.90% considered can define the problem in cycle 1. Then followed by 56.82% can analyze the problem in cycle 2. However, findings revealed most of the students' lack of knowledge and skills to generate and apply the model of the solution to overcome the solution. This is because a smaller number of students can be answered correctly during these stages. The result shows the difficulties happened on solution generation where only 47.72% contributed to the result in cycle 3. Lastly, in cycle 4 only 6.82% can apply a sound and good solution.

Table 1: Summary Result of Test

Item	*f*	%
Cycle 1		
Question 1	29	65.90
Cycle 2		
Question 2	25	56.82
Cycle 3		
Question 3	21	47.72
Cycle 4		
Question 4	3	6.82

Thus, it can be concluded that the issue of lack of basic problem-solving knowledge and incompetence in skills occurs among the local technical students. Therefore, to support the difficulties mentioned, the questions and the exercises attempt should be addressed to be included in the module designed.

Phase 2

Based on the findings in phase 1, then the module was developed. The design module consists of the scheme of work, lesson plan, intervention slide, exercise sheet, problem-solving test and also assessment rubric. The scheme of work has been used as a view or guide in the implementation of the module for a whole lesson. Meanwhile, lesson plan contains a detail instruction of the lesson for guiding achieving of learning outcome in each class.

The intervention slide was used to facilitate the process of delivering information during intervention class and students need to attempt the exercises to support their understanding. The exercises in the module designed covered all the cycle in the research. Example of the exercises and the questions were shows in Figure 6. Students must attempt all the exercises in the module to support their problem-solving skills

CASE STUDIES :	
A. PROBLEM:	
B. CAUSES	**C.** IMPACT

Figure 6: Example of Exercises in Designed Module

Furthermore, problem solving tests were referred as an assessment instrument used in this study. A semester prior before research began an instrument was tested onto 70 students with Cronbach Alpha 0.71. This value shows the inferences made from the result of an alpha above 0.7 is normally considered to indicate a reliable set of items and indicates acceptable reliability. (Johnson and Christensen, 2008: Pallant, 2007). A problem-solving test questionnaires consist of 12 questions was adapted from the TRIZ Innovation Situation Questionnaires (2010) with some modifications to suit the research study objectives and the content was validated by experts in the field. Each cycle was catered by 3 questions and each question has their own marks. Example questions in of problem-solving test were shown in Figure 7.

Describe the system function.

Label the component in the system.

Construct a statement to show the engineering contradictions in the system.

Figure 7: Example of Problem-Solving Test

Table 2 shows the mapping of question number in problem-solving test questionnaires into four cycles of being tested. Lastly, an assessment rubric was used to assess students answer in problem-solving test. There are five scales (very good, good, average, poor and very poor) been used to shows students achievement based on their total marks.

A second-year students in semester four were chosen as samples in this study. They are from Industrial Mechatronics Programme and also Manufacturing Programme. Justifications in selecting both these programmes are because they have the similarity for entry requirements as well as the syllabus. The students also had been exposed to project work in semester 3. Then, students were divided into two groups: control and treatment group. Pre-test was done for both groups in week 9 of the academic semester. An intervention class was implemented during week 12 to 16 of an academic semester with 6 class session for the treatment group only. Whereby control group was remain with the traditional method. Then in week 17, a post-test was done for both groups again.

Table 2: Question Number and Cycle Tested

Question No	Cycle Tested
1	CYCLE 1
2	
3	
4	CYCLE 2
5	
6	
7	CYCLE 3
8	
9	
10	CYCLE 4
11	
12	

Phase 3

The analysis result had been made by comparing marks between each cycle to show students problem-solving achievement. The score obtains from the pre and post test were analyzed quantitatively. Figure 8 shows the result for both groups in the pre-test. Group 1 represent the control group with 33 students were involved, whereby group 2 represent treatment group with 35 students.

The finding shows in Figure 8, both groups almost had the same level of problem-solving skills based on their total marks which are poor and moderate level in their pre-test. Meanwhile, the result in Figure 9 shows a result of total marks for post-test.

Result findings show an achievement for group 1 still remained since they are not exposed to module intervention. However the group 2 shows some improvement in their total marks with the increment number of students in moderate and good level.

Figure 8: Total Marks in Pre-Test

Figure 9: Total Marks in Post-Test

Furthermore, the comparison in the mean point for both groups in both tests was made as shown in Figure 10. From the paired sample T-test, initially, both groups were considered having an equal level of their problem-solving skills. It clearly can be seen when the mean score for control group (blue line) was 22.0 and treatment group (red line) was 22.69. Furthermore, a mean point for control group is not many changes in post-test with mean score 22.15, whereby a mean score for treatment group was increase to 26.20. It significantly changes the level of student problem-solving skills after they exposed to the designed module.

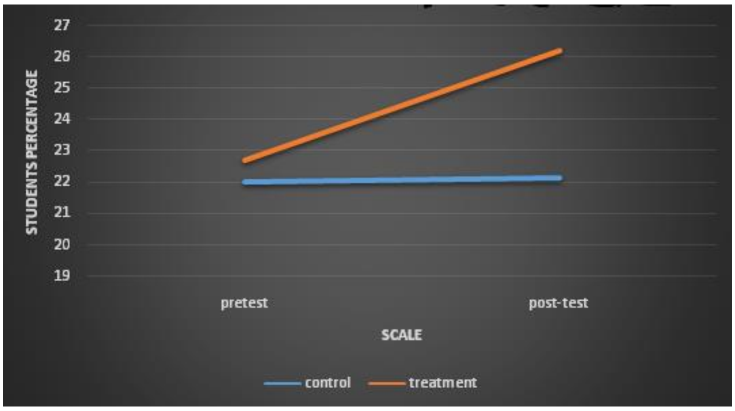

Figure 10: Mean Score For Pre And Post-Test

Discussion and Conclusion

The study found most of the students less difficulties in defining and analyzing the problem. It clearly indicates they had difficulties in generating the solution and also apply the sound solution because of lacking knowledge in problem solving skills techniques. However, there is significant improvement after expose to the module intervention. Each cycle shows an improvement after module intervention. Thus, it can be concluded by increasing the exercises and studying the various aspects of exercise activity can support and enhance the student problem-solving skills. Also, the module can be proposed to be embedded into a part of the course syllabus so that it can be more effective with some modifications and improvement need to be considered while designing the module.

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