DEVELOPMENT AND VALIDATION OF TRIZ-BASED MODULE FOR ENHANCING PROBLEM SOLVING SKILLS IN TVET FINAL YEAR PROJECT

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DEDICATION

This thesis is dedicated to my beloved family for their support in accomplished of this study.

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ABSTRACT

Problem solving skills are one of the most important aspects of soft skills and they are an indispensable feature of becoming a competent and competitive worker. However, industries response showed that today's graduates are unable to meet the industry's needs because of their lack of this skill. Therefore, to address this issue, an approach known as TRIZ-Module has been introduced. This module was implemented in some final year projects of students studying in tertiary education in Malaysia. In this study, critical aspects of problems are solved based on engineering principles on conflicts handling. The Experience-Based Learning theory was also the basis for the implementation of the module intervention of this study. The development process followed five steps of ADDIE Model for conflicts to be minimized and systematically resolved. The respondents of this study were students majored in Manufacturing Technology and Mechatronics Industrial Technology Engineering from Kolej Kemahiran Tinggi MARA Balik Pulau. The study respondents were divided into two groups which were the control group and the treatment group. To investigate the effectiveness of the intervention, only the treatment group was selected to undergo the intervention. Meanwhile, the control group continued to learn using the existing method. This research instrument used questionnaires that had been tested for validity and reliability. The findings data was analysed by using SPSS software using the T test method before and after the test. The findings revealed that the respondents had a better understanding on problem solving. It was indicated through their grades.

ABSTRAK

Kemahiran menyelesaikan masalah adalah salah satu aspek kemahiran insaniah yang paling penting dan merupakan ciri yang sangat diperlukan untuk menjadi pekerja yang kompeten dan kompetitif. Namun, maklumbalas dari industri menunjukkan bahawa graduan sekarang tidak dapat memenuhi keperluan industri kerana kekurangan kemahiran ini. Oleh itu, untuk mengatasi masalah ini, pendekatan yang dikenali sebagai *TRIZ-Module* telah diperkenalkan. Modul ini dilaksanakan melalui projek tahun akhir pelajar di sebahagian institusi pengajian tinggi di Malaysia. Dalam kajian ini, aspek kritikal masalah diselesaikan berdasarkan prinsip kejuruteraan tentang pengurusan konflik. Teori Pembelajaran Berasaskan Pengalaman juga menjadi asas bagi pelaksanaan intervensi modul. Panduan proses pembangunan mengikut lima langkah Model ADDIE supaya konflik diminimumkan dan diselesaikan secara sistematik. Responden kajian ini adalah pelajar jurusan Kejuruteraan Teknologi Pembuatan dan Kejuruteraan Teknologi Mekatronik Industri di Kolej Kemahiran Tinggi MARA Balik Pulau. Responden kajian dibahagikan kepada dua kumpulan iaitu kumpulan kawalan dan kumpulan rawatan. Untuk mengkaji keberkesanan intervensi, ianya hanya melibatkan kumpulan rawatan. Sementara itu kumpulan kawalan terus belajar menggunakan kaedah yang sedia ada. Instrumen kajian ini menggunakan soal selidik yang telah diuji kesahan dan kebolehpercayaannya. Dapatan kajian dianalisis menggunakan perisian SPSS melalui ujian T pada sebelum dan selepas ujian. Hasil kajian mendapati pelajar lebih memahami dan mengetahui cara menyelesaikan masalah. Ini ditunjukkan melalui nilai gred yang diperolehi oleh mereka.

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LIST OF ABBREVIATIONS

MQA	-	Malaysia Qualification Agency
MQF	-	Malaysia Qualification Framework
MARA	-	Majlis Amanah Rakyat
KKTM	-	Kolej Kemahiran Tinggi MARA
FMM	-	Federation of Malaysian Manufacturers
PS	-	Problem Solving
IT	-	lndustrial Training
UTM	-	Universiti Teknologi Malaysia
TRIZ	-	Theory of Inventive Problem Solving
FYP	-	Final Year Project
ELT	-	Experiential Learning Theory
ELC	-	Experiential Learning Cycles
CLO	-	Course Learning Outcomes
PLO	-	Programme Learning Outcomes
PEO	-	Programme Education Outcomes
CE	-	Concrete Experience
RO	-	Reflective Observation
AC	-	Abstract Conceptualization
AE	-	Active Experiment
TVET	-	Technical Vocational Education and Training
RO	-	Research Objective
RQ	-	Research Question
OBE	-	Outcome Based Education
MoE	-	Ministry of Education

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The higher education system in Malaysia has made much improvement since 1957 especially in terms of the number of graduates produced to prepare the workforce for both public and also private sectors (Ministry of Education Malaysia (MoE, 2017). The manufacturing sector has experienced an increment in employment for technical workers and middle-level professionals (EPU, 2018). The numbers of workforce with employability skills were very important to fulfill the demand by the industries in the future.

Malaysia needs to restructure its workforce to ensure that middle-level workers are highly skilled. Malaysian future workforce has to be able to cope with the changing nature and demands of works (Husaina, 2019). Hence, the importance of Engineering education to support Malaysia to become an industrialized country is needed in providing technological innovations towards the development of society. Without technological innovations, human development becomes slow, less economic growth and also lack of new production.

Demand for the employers was more on good workers with good skills in communication, writing and also higher-order thinking such as independent learning, good in problem-solving and creative thinking. These job competencies must be owned by each graduate. However, the reason for the employability weaknesses in Malaysian graduates as they are inefficient in the workplace. They lack the skills required by the industry to become a good skilled worker that capable of doing a task efficiently (Zulkifli, 2016). Lack of soft skills has contributed greatly to graduate unemployment in Malaysia (Ranjit, 2017).

Therefore, a paradigm shift in instructional and learning systems needs to be emphasized so that it relevant to the desired learning outcomes and also able to minimize the lack of problem-solving skills among Malaysian graduates (Adnan & Daud, 2017).

1.2 Research Background

An employability skill is a set of achievements, understanding, and personal attitudes or qualities for graduates to get the desired job and successful in a career (Nooriyah & Zakiyah, 2016). This skill needed by students to prepare themselves to meet the needs of many different occupations upon graduation (Shafie & Nayan, 2017). Salbiah (2016) stated that employability skills can be summarized as vital skills for securing employment, which include basic skills in reading, writing, arithmetic, and thinking and problem-solving skills.

While graduates are well equipped with technical skills but they are lacking soft skills which are very important at the workplace. It seems graduates cannot apply their knowledge to solve and faced the problem or new problem even though it is a routine problem. Additionally, communities also require graduates who are not only knowledgeable but also using skills that can solve, analyze, synthesize, evaluate and assess contemporary problems.

A human capital drive in the future, graduates should equip themselves with critical thinking and problem-solving skills as it is requested from employers in finding skilled workers (Rodzalan & Saat, 2015). Based on Shute (2016) states it is very important to develop good problem-solving skills to maintain and produce a quality graduate. This supported by Noor Suhailie (2018) that found a gap between the employer and graduates includes problem-solving and adaptability, English language and literacy, information, communication and technology, personal organization, leadership and communication skills.

Therefore, education for human capital development in higher education in Malaysia requires a shift by expanding opportunities to gentle a transition from education to the workplace. Hence, the government has identified the need to strengthen the teaching and learning system by incorporating soft skills in the current higher education curriculum. This supported by Chiu (2016) mentioned developing a soft skills competency should be a priority of Higher Educational Institutions to ensure a graduate become marketable in the future.

Therefore, it more focuses on increasing the quality not just quantity of education and at the same time providing young people with a platform for civic engagement. Besides, some of the requirements in the Malaysian Qualification Framework (MQF, 2019) undergraduate students must able to apply comprehension, knowledge, and practical skills at work. Also, they must able to decide and assess, involve in account social, thinking in scientific and ethical issues with moderate autonomy. Nowadays, it's not enough for students to face and compete with global development through technical skills only. Furthermore, apart from the excellent achievement in academics and skills, they also need to have soft skills such as effective communication, leadership, teamwork, innovation, and creativity. Improving the ability of individuals and groups in solving a problem and make decisions is an important issue in the industry, government, and education as well.

Apart from recognizing learning domains; affective, cognitive and psychomotor the Ministry of Education also emphasized nine others learning outcomes which are significant for Malaysia and it is important to provide quality education to students and one of the elements that frequently be debated in the professional context is problem-solving skills. Malaysia Higher Education had already emphasized the soft skills in education systems including a Technical and Vocational Education and Training (TVET) system. Majlis Amanah Rakyat (MARA) is one of the agencies in Malaysia to implement TVET in their technical education systems with the education outcomes as shown in Appendix A.

As a TVET agency, the mission of Kolej Kemahiran Tinggi Mara (KKTM) is spearheading the vocational and technical education to produce integrity, competent and innovative human capital. Also, to fulfill the mission the students need to be an

innovative problem solver by increasing the level of problem-solving skills. Moreover, to support the KKTM mission, one of the Programme Educational Objectives (PEO) in KKTM has the sub-element problem-solving in soft skills elements to produce graduates with adequate knowledge and technical skills to perform their job tasks in the related field and possess lifelong learning attributes. This element can be catered towards the learning outcomes for the final year project course which the students should be able to produce a project with good documentation and presentation.

However, it seems students do not know how to solve the project problem (Uziak, 2016). Most of the time students able to acquire knowledge but do not know how to use it to solve the engineering technical problems. Furthermore, one of the methods that can improve problem-solving skills is learning through a project (Lasauskiene & Rauduvaite, 2015). The student-centered learning approach method allows students to participate in learning environments, independent, responsible for their learning, decision developing, understanding and organizing information (Fitryah, 2018). In the project, the students need to solve the problem and then translate the result into documented or report. Although teaching is considered as an input that directs the learning process an open-ended solution is more focused on applications and assimilation of previously acquired knowledge.

Nowadays problems are getting more complex and complicated because it interrelates with various fields. This situation is more in line with current and future demands as the needs of the workforce can solve the problem innovatively and effectively. It is very different from the old problem-solving method that relies on knowledge in specific fields only. Problems arise more complex than ever, the workforce is required to come out with innovative solutions. Solving similar technical problems requires experience from a particular field of work. Problem-solving skills are very important for graduates so that they can fulfil the needs of industries in line with the rapid growth of technology.

Meanwhile comments from experienced lecturers and based on students' written solutions in their project report and presentation as well as observations made during the monitoring of final year project work progress also indicate

students having difficulties in solving the technical problem. As an initiative towards empowering TVET Malaysia, MARA has implemented industry training as a condition for graduation. Students will be evaluated from various aspects including soft skills where there are elements in problem-solving skills been assessed as shown in Figure 1.1. The purpose of these elements also in line with MARA education outcome as stated in Appendix A. However, discussions with the industry during the practical training visits most of the students indicate they are less exposed to problem-solving techniques. Students often wait for directions in solving problems due to a lack of knowledge and inexperience.

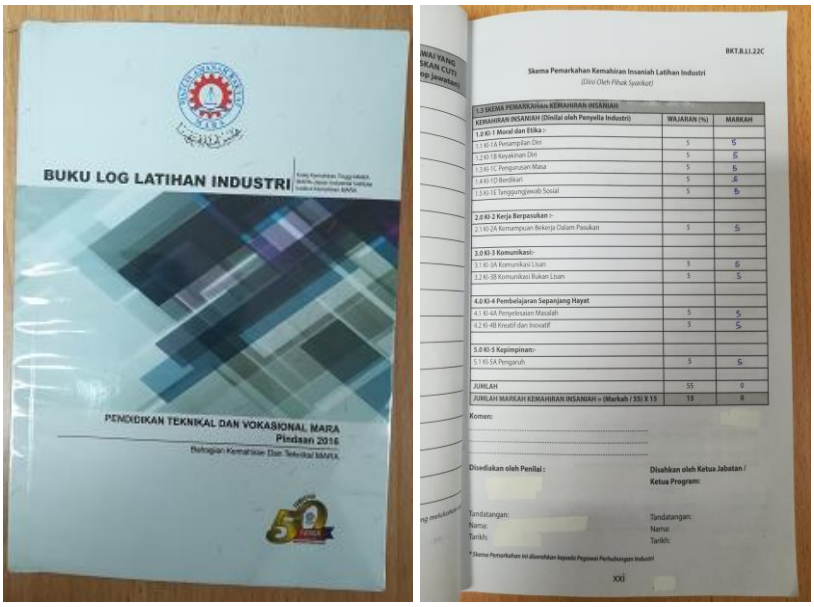

Figure 1.1 Logbook industrial training (BKT MARA, 2016)

Also, the comments mentioned in the industry training report stated the same thing where students need more training and exposure to the theory of problem-solving as illustrated in Figure 1.2. The report mentioned students not able to identify the main issue to form a detailed image of the problem. They lack problem-solving skills and inactive to explore the potential solution and therefore, they are not able to come up with good approaches. This scenario also happened during their studies. Students are seen to have difficulties in problem-solving, especially during their final year project. They struggle or difficulties in problem-solving due to confusion, misinterpretation, inadequate practical and thinking skills, and lack of knowledge in problem-solving tools.

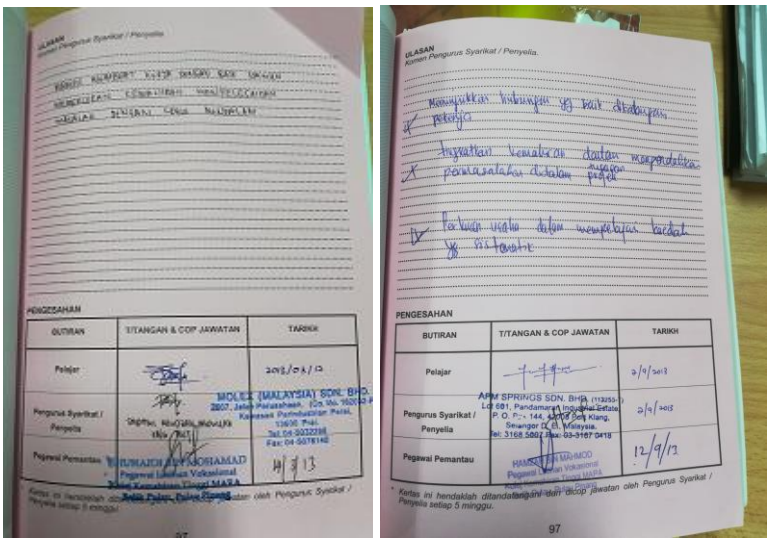

Figure 1.2 Practical training report (BKT MARA, 2016)

1.3 Students' Current Problem-Solving Skills at KKTM

Discussions between the industry and KKTM Academic Committee are always ongoing in ensuring a course is still relevant in the market. Among the findings emphasized is that students must always be prepared to solve and analyze problems systematically. Abilities in problem-solving skill are not just knowledge gained from experience but it also can be trained so that graduates become experts and dynamic. Hence forward it also can promote students the opportunity to understand learning flexibly in various activities. With their style, students tend to study in-depth, investigate, present ideas and understand the problem. The experience gained through this problem-solving method helps students become responsive, progressive, confident and creative. This matter is also supported by the KKTM Alumni Committee from the survey to measure the effectiveness of the program conducted, where some respondents provide feedback with suggestions that theories or methods in problem solving should be included in the final year learning because it supports the elements of graduate marketability. They also mentioned, in the industry such skills are very much needed especially to identify a problem that occurs in a process either in terms of technical or management as well as it also supports critical thinking.

Furthermore, comments from sector industries and report written in industrial practical training also mentioned there are still graduates who do not meet industry requirements which always demands workers to solve the problem quickly and efficiently. The issue also documented by the Malaysian Employers Federation (2016) that mentioned graduates in Malaysia lacked potential criteria as a competent worker. In addition, from general observation of the students' project presentation, interview among students and lecturer, student tend to show the unstructured thinking, overgeneralization of procedure, trial and error and always depend on rote learning of the previous project carried out by their seniors. The effect on this situation may due to the current syllabus Final Year Project course where it does not take into account the importance of problem-solving skills. The drawbacks to the current students' problem-solving skills that can be highlighted are:

1. The learning objective and learning outcomes of problem-solving skills are not clearly stated in most technical engineering education programs.
2. The standard method for evaluating problem-solving skills is not available.
3. The assessment of final year projects focuses on the output of the project whereas students' problem-solving process is not being assessed.
4. The design of the traditional problem-solving method in the final year project does not support students' structured thinking.

1.4 Problem Statement

Students are seen to have difficulties in problem-solving techniques which hinder their structured thinking. One of the difficulties is they are not being able to solve problems due to a lack of systematic thinking in problem-solving skills. Also, there are reasons for this research to investigate students' problem-solving skills because the end of the semester students has to produce a project in their final year project course. The course is compulsory for students before they leave their studies and go to industrial training. Also, it culminates in the lessons to provide opportunities for students in synthesizing and apply their knowledge and experiences from their whole studies.

It helps them in transition to the next stage of their career. Some students were able to describe the method they would use to solve the problem but sometimes they used an inappropriate strategy such as trial and error method which does not contribute to the development of their problem-solving skills at all. Besides, feedback from industrial sectors and as mention in industrial training report, students' still shows poor problem-solving skills especially in solving the project problems during their industrial attachment. Therefore, this research is to find out if by intervention of the TRIZ module can help students enhance their problem-solving skill.

1.5 Research Objectives

This research aims to enhance students' problem-solving skills by introducing a module using TRIZ combined with Kolb methodology and ADDIE model that focuses on the final year project course. The project requires the students to use all their knowledge and skills in solving a problem and thus can provide an indicator of students' understanding of the knowledge and acquisition of the skills taught in the program. At the same time, students can experience the method in the structure and systematic way. The module had been implemented in the Final Year Project course. The main objective of this research is to study and develop teaching materials through the designed module to support and enhance students' problem-solving skills.

The research objectives (RO) can be expressed in more detail as follows:

R01. To investigate students' problem-solving difficulties in Final Year Project course.

R02. To develop the intervention module known as TRIZ.

R03. To evaluate the intervention module - TRIZ.

1.6 Research Questions

To achieve the above research objectives, the following research questions (RQ) were used as a guide in the study:

RQ1. What are students' problem-solving difficulties in Final Year Project?

RQ2. How the intervention module are develop?

RQ3. What are assessment tools used to evaluate the intervention in module - TRIZ?

1.7 Theoretical Framework

The framework used as shown in Figure 1.3 based on Experiential Learning Theory (ELT) by Kolb describes a term of experiential focus and emphasis on the aspect which experiences act in the learning process and also as the foundation of learning. Meanwhile, knowledge was formulated via the transformation of experience. Hence, this is the main reason and justification for implies it as a framework. Furthermore, learning can be described as a holistic adaptive process that provided conceptual bridges across life situations such as school and work. Therefore, from the experimentation and experiences, it can be described as the way people make sense of the world. This would make a better understanding in different ways.

The Experiential Learning Cycle (ELC) begins from concrete experience. Then it moves forward into reflections and observations. Next, it leads to abstract conceptualization that promotes a new idea and thinking. Moreover, new thinking creates active experimentation which applies the new learning and creating a new experience. Besides that, the cycle allows an individual to repeat and begin at any stage. It is viewed as an integral part of how humans learn, grow and develop (Kolb, 1984). Learning becomes truly ‘experiential' only if all four phases of the learning cycle are addressed. The model described four learning styles based on the stage of

the learning cycle. Diverges need to observe and collect a wide range of information; prefer to work in groups, listen with an open mind and to receive personalized feedback.

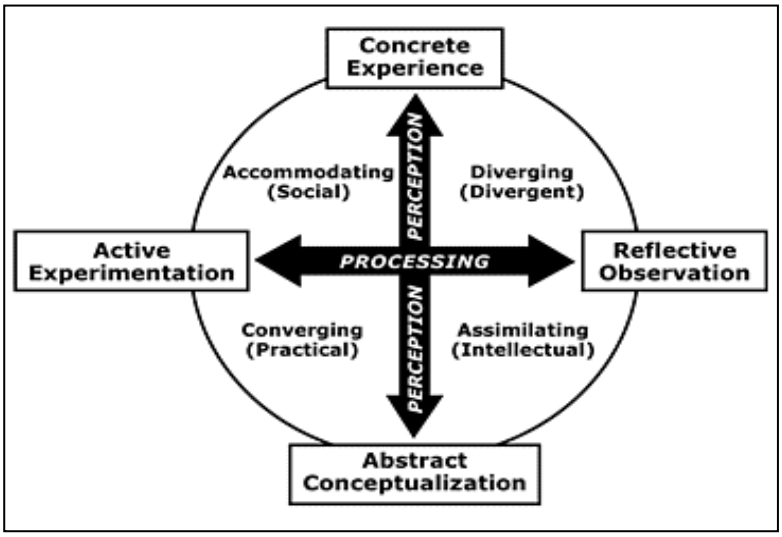

Figure 1.3 The Experiential Learning Theory (Kolb, 1984)

Assimilators need sound logical theories to consider; less focused on people and more interested in ideas and abstract concepts. Converges need practical applications of concepts and theories, for example, creating new ideas, laboratory assignments, simulations, and also practical applications. Meanwhile, Accommodators need hands-on experiences, prefer to work with others to gets assignments done, do fieldwork and test out different ways to complete a project. For the study, the ELT was considered a better fit because it provided conceptual connections across life experiences. Learning by the project provides an effective approach to creating a classroom environment with authentic tasks as the major focus and enable the students to reflect on and evaluate their understanding. Also, Kolb's ELT describes the study based on meaningful and authentic experiences for understanding how learning takes place.

The process portrays an idealized learning cycle and the learner has attempted through each of the stages - experiencing, reflecting, thinking, and acting in response to the learning situation and what was being learned.

1.8 Conceptual Framework

The conceptual framework is a mechanism for aligning literature review, research design and methodology (Maxwell, 2016). The conceptual framework is based on the question of what, how and when that needed to be considered when designing the intervention module. The framework describes the whole process of module development. It is based on the question of what, how and when that needed to be considered during the process. In addition, the input, output and the actual process of teaching and learning are also clearly defined.

The conceptual framework for the study was shown in Figure 1.4. The input of the study is about the current problem-solving skills. Then finding of the input is considered while designing a module. While several studies have developed and merged Kolb's ELT and models to manage problem-solving activities, the potential contribution of the TRIZ theory to develop a structured problem solving has not been much explored yet. Therefore, this research is to fill this gap, by combining the Kolb Experiential Learning Theory with the TRIZ principles.

This study designed a module implement in the Final Year Project course was based on steps in ADDIE model. Furthermore, the output discusses the issues in this research, then translates it into students' achievement in problem-solving skills after being subjected to this educational process experimentation.

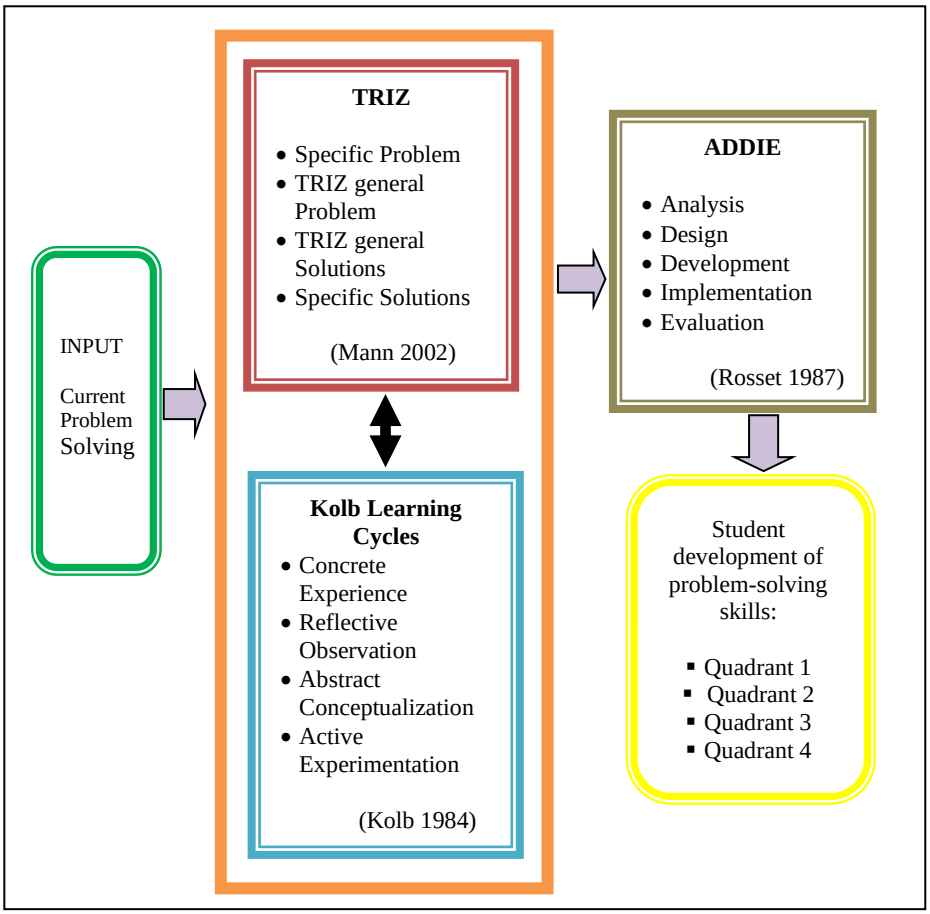

Figure 1.4 Conceptual Framework

1.9 Significance of the Research

The study can provide empirical evidence supporting the effectiveness of experiential learning with TRIZ Based Module on positively impacting academic achievement in theoretical and practical implications in the areas of professional development, curriculum design, and resource allocation. The results of the study are used to explore further expansion and continue to change the conception of learning by moving away from the teacher as the purveyor of knowledge and the learners as passive receivers. The rapidly changing world has increased our demand for flexibility to leverage previous knowledge and experience in new and different ways. This could help the educators to find new ways to help students learn and to design effective learning and experiential techniques. The findings of this research can be used as a contribution to enhancing the problem-solving skills in the final year project course.

1.10 Scope and Limitations

The purpose of this research is to enhance students' problem-solving skills among engineering technology students in Majlis Amanah Rakyat (MARA) Higher Technical Education in Malaysia. The scope of the study focuses on the Final Year Project (FYP) for second-year students in the Diploma Engineering Technology Programme of Industrial Mechatronics and Manufacturing Technology at Kolej Kemahiran Tinggi MARA Balik Pulau. The module designed associated with the experiential learning theory and theory inventive problem-solving in defining teaching strategies, learning outcomes and also assessment strategies. The students involved are in semester 4^{th} that already registered final year project 1 course for session January - June 2017. The research conducted is for one semester only and the respondent was from 68 students.

1.11 Operational Definition

The following terms are commonly used in this research.

1. Generic Skill

The Generic Skills refer to attributes in personal skills. Examples of the skills were problem-solving skills, critical thinking, teamwork skill, communication skills, and professional ethics.

2. Achievement

The accomplished or to which extent that students can perform to interpret the result of learning. In this study, achievement refers to the outcomes of the module designed on students' problem-solving skills after having an intervention.

3. Final Year Project (FYP)

Refer to the project that the student needs to produce in the final year of the studies. It describes the culmination of the whole study in the institutions and by giving a demonstration to what they have developed and learned.

4. Learning Outcomes

Learning outcomes are insights that must be known, understood and practiced by students in or after completing a learning period.

5. IHL

Institution of Higher Learning.

6. Experiential Learning

Experiential learning theory used knowledge and experience as a learning method.

7. TRIZ

Theory of Inventive Problem Solving is a structured approach towards inventive and structured problem-solving.

8. ADDIE

Addie is refers to five stages of a development process: Analysis, Design, Development, Implementation, and Evaluation.

9. BKT MARA

Bahagian Kemahiran dan Teknikal, Majlis Amanah Rakyat or Technical and Skills Divisions, People's Trust Council .

1.12 Summary

This chapter discussed the research background, problem statement, framework used, research objective and research question, significance and also the scope of the study. Students' current difficulties have also been discussed so that it can be considered while developing a module to ensure students can explore problems by working with other peers and resources.

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