RELATIONSHIP BETWEEN METACOGNITIVE KNOWLEDGE, METACOGNITIVE MONITORING AND SELF-REGULATION DURING PROBLEM-BASED LABORATORY AMONG FINAL-YEAR ELECTRICAL ENGINEERING STUDENTS OF UNIVERSITI TEKNOLOGI MALAYSIA

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DEDICATION

I dedicate this thesis to my dearest parents who always encourage and support me through my master journey. This thesis also dedicated to my supervisor Dr Narina who always guide me and inspire me.

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ABSTRACT

In order to solve a problem, metacognition is needed, as it triggers the learning of the individuals. The learning skills are very important to the engineering students as it developed the students to solve the problem through the engineering curriculum as well as experiences in life. There are three main objectives in this study, which are (1) to identify the metacognitions' level of the engineering through the problem-solving process, (2) to examine whether there is difference exist in the level of the metacognitions between the two phases, which are Phase 1: problem identification and Phase 2: strategy development and problem-solving process and (3) to observe whether there is relationship exists between the Metacognitive Knowledge and Metacognitive Monitoring and Self-Regulation when the students undergo the problem-solving process in the problem-based laboratory. Questionnaire established by Rakib (2019) were administered using Google Forms to gather the data for the study. The questionnaire consisted of 149 items and through the purposive sampling method, the study had obtained 128 responses from final-year electrical engineering students who studied in Universiti Teknologi Malaysia. The four metacognitions' level, which consisted of Metacognitive Knowledge in Phase 1, Metacognitive Monitoring and Self-Regulation in Phase 1, Metacognitive Knowledge in Phase 2 and Metacognitive Monitoring and Self-Regulation in Phase 2 were moderately high. There was a significant difference between Metacognitive Knowledge in Phase 1 and Phase 2, as well as Metacognitive Monitoring and Self-Regulation in Phase 1 and Phase 2, as the p-value is less than 0.05. The significant correlation between Metacognitive Knowledge in Phase 2 and Metacognitive Monitoring and Self-Regulation in Phase 2 were found to be very strong. While the significant correlation between Metacognitive Knowledge in Phase 1 and Metacognitive Monitoring and Self-Regulation in Phase 1 were found to be strong. The data collected from this study might be helpful for the facilitators in understanding the metacognitive of the students and they would be able to provide guidance to the students in enhancing their skills in solving problem.

ABSTRAK

Untuk menyelesaikan masalah, metakognisi adalah sangat diperlukan. Ini adalah kerana ia membantu seseorang untuk mahir dalam pembelajaran. Kemahiran ini adalah sangat penting untuk pelajar kejuruteraan dengan membantu pelajar tersebut menyelesaikan masalah terhadap pendidikan kejuruteraan dan pengalaman mereka dalam hidup. Terdapat tiga tujuan utama dalam kajian ini, (1) untuk mengenalpasti tahap metakognisi pelajar apabila mereka menyelesaikan masalah, (2) untuk meneliti sama ada terdapat perbezaan antara tahap metakognisi dalam kedua-dua fasa, iaitu Fasa 1: pengenalan masalah dan pembangunan strategi dan Fasa 2: proses menyelesaikan masalah sebenar dan (3) untuk mengkaji sama ada terdapat perhubungan antara Metakognitif Pengetahuan dan Metakognitif Pemantauan dan Regulasi Kendiri apabila pelajar menyelesaikan masalah di makmal berasaskan masalah. Soal selidik yang disediakan adalah dihasilkan daripada kajian yang dibuat oleh Rakib (2019). Soal selidik disediakan dalam Google Forms untuk mendapatkan data melibatkan 149 soal selidik. Dengan melaksanakan teknik persampelan bertujuan, seramai 128 reponden dalam kalangan pelajar tahun akhir yang mengambil program ijazah Kejuruteraan Elektrik di Universiti Teknologi Malaysia telah terlibat sebagai responden kajian. Berdasarkan empat metakognisi yang dikaji untuk kajian ini, Metakognitif Pengetahuan dan Metakognitif Pemantauan dan Regulasi Kendiri dalam Fasa 1 dan Fasa 2 adalah sederhana tinggi. Terdapat perbezaan yang signifikan antara Metakognitif Pengetahuan dalam Fasa 1 dan Fasa 2. Perbezaan yang signifikan antara Metakognitif Pemantauan dan Regulasi Kendiri dalam Fasa 1 dan Fasa 2 juga dikenalpasti. Ini kerana nilai p adalah kurang daripada 0.05. Dapatan kajian mendapati terdapat hubungan yang signifikan di antara Metakognitif Pengetahuan dan Metakognitif Pemantauan dan Regulasi Kendiri dalam Fasa 1 dan Fasa 2. Dapatan juga menunjukkan hubungan yang signifikan di antara Metakognitif Pengetahuan dan Metakognitif Pemantauan dan Regulasi Kendiri di Fasa 1. Manakala korelasi signifikan antara Metakognitif Pengetahuan dengan Metakognitif Pemantauan dan Regulasi Kendiri dalam Fasa 1 adalah kuat. Kajian ini membenarkan fasilitator untuk memahami secara mendalam terhadap proses pemikiran pelajar. Ini akan dijadikan bimbingan untuk pelajar bagi meningkatkan kemahiran mereka dalam penyelesaian masalah.

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LIST OF ABBREVIATIONS

H_0	-	Null Hypothesis
N	-	Sample Size
SD	-	Standard Deviation
Sig.	-	Significance Probability
Asymp. Sig.	-	Asymptotic Significance

LIST OF SYMBOLS

%	-	Percent
t	-	t-score
df	-	Degrees of freedom
R^2	-	Squared multiple Correlation
p	-	p-value

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In the 21^{st} century, engineering education has called upon to change, due to the challenges face in the exist and future practice. This is owing to the requirements on engineering graduates in the workforce to possess the skills needed. Even though some of the engineering education still emphasize on teacher-centred delivery, which is through conducting lectures and recipe-type laboratories. Engineering education has slowly adapted to the student-centred learning, which require the students to form analysing skills, problem-solving skills, innovative skills, collaboration skills etc. to prepare them for solving complex problem in their future employment as engineers (Mohd-Yusof et al., 2015). This is proven by Swart (2010) that many Malaysian universities have adopted problem-based learning in teaching the engineering graduates to gain the required characteristics. In Universiti Teknologi Malaysia, the final-year electrical engineering graduates have been required to attend problem-based laboratory, which they are given tasks by the facilitators to solve the problems in a group that resemblance to the engineering industry problems (Azli et al., 2012).

Problem-based learning is defined as the teaching approach that is student centred. It requires the students to do research, implement theory learned and skills in order to solve a given problem. The skills developed from the problem-based learning include analysing skills, critical thinking skills, collaboration skills and others. With problem-based learning, it induces metacognitive skills of the students, as students involve themselves in self-learning. Lecturers merely take the role of facilitators (Savery, 2015). Problem-based learning fit well into engineering education as it moulds the students' ability in order to apply what concepts they have learned to the real-life problems. This has helped the students to develop themselves towards expertise in supplying students with life-long learning skills (Yadav et al., 2011).

In order to solve a problem, metacognition is needed. Metacognition is the process where the students predict the available knowledge and skills needed for the task and apply what has been learned (Winne & Azevedo, 2014). Metacognition is important for the engineers as according to Davis et al. (2013), when engineers are given complex problem to solve, they refer on the past activities and attainments, make decisions, take action, obtain the meaning and assess other options. For example, engineers must know the new technologies that could be applied to solve the problem and from there, they establish new concepts for the solution. When the next time they need to deal with new problem, they need to analyse whether the existing concepts is applicable and if its not they need to repeat the steps to enhance the solution.

1.2 Background of Study

According to Department of Statistics Malaysia (2020a), the number of undergraduate students has increased from 4.9 million in the year of 2018 to 5.3 million last year. However, upon graduation, not all undergraduate students are being employed, among 5.3 million of the graduates, only 4.25 million of them were involved in the workforce (Department of Statistics Malaysia, 2020a). Whereas, 170.3 thousand of them were unemployed (Department of Statistics Malaysia, 2020b). This shows that even as an undergraduate, it does not promise that there will be job vacancy offered for the undergraduate (Leo, 2019). This is because the Malaysian employers are more emphasized on getting candidates who possess soft skills, which are able to think creatively, flexible, able to work in a team (Thomas, 2019), able to solve problem, communicate, manage own self (World Economic Forum, 2020a), possess leading skills, interaction skills (Nair, 2018) and having positive thinking (Jobstreet, 2016) rather than only possess the hard skills, which is the academic knowledge they gained from undergraduate studies (Nair, 2018). Among the soft skills mentioned above, problem-solving skills, time allocation skills, communication evaluation skills are the soft skills that makes the graduates stands out from all the candidates (World Economic Forum, 2020c).

However, due to the COVID-19 pandemic, there are lots of people asked to leave the jobs in United States (World Economic Forum, 2020b). According to Kamaruddin et al. (2020), the unemployment rate in Malaysia has risen up to 826,000 persons in May (Kamaruddin et al., 2020). Based on the Department of Statistics of Malaysia (2020a), 35.4% of the workers in food and beverages companies lose their jobs, 21.9% of the workers in agriculture lose their jobs, 11.8% of the workers from the construction fields lose their jobs as well as 46.6 % of the self-employed workers lose their job during COVID-19 pandemic. Besides, Kamaruddin et al. (2020) stated that with the slowdown of economic during COVID-19 pandemic, the employment of the graduates will be quite low when considering with the employment expectation in the post COVID-19, as most of the employers will cut down the number of employment of graduates (Institute of Student Employers, 2020), comprises of the industry of engineering (Nortajuddin, 2020). Bin Ammeran (2020) claimed that this phenomenon will continue on until next year. When consider with the 300,000 fresh graduates in each year (Department of Statistics Malaysia, 2020a), graduates have to compete themselves with other employees who are unemployed. It is estimated that by the Ministry of Higher Education (MOHE) that from 300,000 fresh graduates, 75,000 of them will not be employed in 2020 as a result of the COVID-19 pandemic (Eduspiral Consultant Services, 2020). To secure the jobs, the employees or jobseekers are required to upgrade their skills especially the digital skills, as well as expand other soft skills such as problem-solving skills, teamwork skills and be opened to ideas to be in line with the virtual working settings to occupy the jobs, as they need to work remotely most of the time without directly engage with the colleagues (World Economic Forum, 2020b). They are also required to possess leadership skills, being agility, having critical thinking skills, creativity and innovative skills (Lukins, 2020).

Notwithstanding with that, with the COVID-19 pandemic, most of the education divisions were forced to transform the traditional face-to-face teaching to online learning. All courses including engineering course are required to be conducted online after the Movement Control Order was lifted in Malaysia on 28 March, this also include labs and workshops (Nawi et al., 2020). However, few months after the conditional Movement Control Order, Ministry of Higher Education had mentioned that Final-year undergraduate students who require to attend any activities such as engineering students who need to attend the laboratories or workshops, ought to present commence on 1 July by following the standard operating procedures in the university (The Star, 2020). Nevertheless, as the COVID-19 strikes Malaysia again with the second wave in October, the Ministry of Higher Education had announced that all the courses to be shifted online for the safety concern (Sharma, 2020). The largest concern that needs to be addressed in the engineering education is to find out the appropriate way to complete the laboratories work through virtual access, even though virtual laboratories cannot replace the hands-on experience with real-life machines and instruments (Qadir & Al-Fuqaha, 2020). Aiman (2020) added that for engineering courses with compulsory laboratory sessions, workshops and conferences will be suspended up until the students are allowed to go back to the university, to make sure the students gain the learning outcome. This is because with the lack of experience in teaching and learning through online in Malaysia, for engineering laboratory work, students only have to watch videos given by the lecturers and wrote reports or the lecturers have to design self-directed learning to make sure students understand the function of the instruments and the applications of them through online learning, unlike in the past (Nawi et al., 2020). In comparison with that, the Engineering Institute of Technology in Australia has adopted the virtual laboratories and simulation software that is resemblance to the real-world settings, which set a pathway for the future work preparation (Foster, 2020). Even though, Jensen (2020) claimed that in New Straits Times, with prior interaction to online learning, engineering students in Malaysia already obtained the experiencing in cooperate all the digital technologies, which will enhance them in their motivation and self-learning. Self-learning is said to be a crucial element in metacognition as it induces the thinking and self-reflection (Jaewoo & Woosun, 2014). Flavell et al. (2002) stated that metacognition included both Metacognitive Knowledge and Metacognitive Monitoring and Self-Regulation. Metacognitive Knowledge are the knowledge about one’s cognitive matter. While, Metacognitive Monitoring and Self-Regulation are the knowledge in the cognitive processes, includes planning, monitoring, assessing and modifying for solving complex problem.

In spite of the uncertainty brought up by the COVID-19 pandemic, it is not predictable about the how will the education settings will become during the post COVID-19 era (Murphy, 2020). Hence, the findings from this study will be able to provide a better understanding to the researchers on the metacognition of final-year engineering graduates during the problem-solving activities through online learning. The lecturers will also know better of the students’ metacognition skills demonstrated through online learning activities.

1.3 Problem Statement

The purpose of this study is to discover the metacognition level of the final-year electrical engineering students during the phase of problem identification and strategy development and actual problem-solving. Moreover, the correlation between the metacognition, which is the Metacognitive Knowledge and Metacognitive Monitoring and Self-Regulation will be examined, to see if they are relevant to each other.

Zahari (2010) stated that engineers need to modify and improve several skills, which are self-learning skills, problem-solving and other personal skills to be employable in the workforce. With the COVID-19 pandemic, the organization have changed their preferences in opting desirable employees. They will first consider those who were good in using digital resources (Webber, 2020) and other soft skills such as able to solve problem, collaborate with teams, and openness to ideas (World Economic Forum, 2020a), leading others, adaptability, able to think critically, creatively and innovatively (Lukins, 2020). Most of the work will be shifted online (World Economic Forum, 2020b).

In line with this, consider the safety of the students and staffs, all courses in higher education institution has brought up all the courses to online learning. As with the sudden introduce of the virtual learning with the COVID-19, the lecturers are required to construct engineering courses through self-directed learning to make sure that even though psychomotor skills are not available through the face-to-face laboratory session, the students still gain their understanding of the functionality of the instruments and the way to implement the instrument through virtually teaching (Nawi et al., 2020). Nawi et al. (2020) asserted that through online learning, lecturers have become the facilitator, as most of the learning for the students are self-dependent. Also, more discussion and thinking time is granted among the students to voice out their thoughts and opinions, which will induce students to solve the problems, think critically, work collaboratively and able to reflect on themselves.

With the online learning, it compliments with the requirement in engineering workforce, where problem-solving skills, critical thinking skills and collaboration skills are needed to solve complex problem in team (Dringenberg & Purzer, 2018). As stated by An and Cao (2014), to be successful in problem-solving, metacognition is required. Lawanto (2010) claimed that metacognition is a basic tool which allows the students to control their thinking, feeling and motivation. Metacognition is popular in the field of science, technology, engineering, mathematics and others. From the previous studies, metacognition has impact on the improvement of learning, for example, when the engineering students involve in teamwork, it helps the students in managing and interacting in the process of learning and problem-solving effectively.

Metacognition is deemed to be extremely critical to train and develop the engineers in solving problem. It assists in helping them more competent in finding the solutions, while learn from their experiences (Cunningham et al., 2016). Nevertheless, Sandi-Urena et al. (2012) illustrated in her study that students who attended in laboratory program rather than ordinary laboratory course will possess higher metacognition. Hence, this study will examine the metacognition level of students during current laboratory problem-based learning.

1.4 Research Objectives

The following are the aim of the research study:

1) To determine the level of Metacognitive Knowledge among the final-year electrical engineering students in Universiti Teknologi Malaysia during the phase of problem identification.

2) To determine the levels of Metacognitive Monitoring and Self-Regulation among the final-year electrical engineering students in Universiti Teknologi Malaysia during the phase of problem identification.

3) To identify the level of Metacognitive Knowledge among the final-year electrical engineering students in Universiti Teknologi Malaysia during the phase of strategy development and the actual problem-solving process.

4) To identify the levels of Metacognitive Monitoring and Self-Regulation among the final-year electrical engineering students in Universiti Teknologi Malaysia during the phase of strategy development and the actual problem solving process.

5) To investigate the difference in metacognition level of the final-year electrical engineering students in Universiti Teknologi Malaysia during the phase of problem identification and the phase of strategy development and the actual problem-solving process.

6) To determine the relationship between Metacognitive Knowledge and Metacognitive Monitoring and Self-Regulation throughout the process of problem-solving in the problem-based laboratory among the final-year electrical engineering students in Universiti Teknologi Malaysia.

1.5 Research Questions

The research questions of this study are:

1) What is the level of Metacognitive Knowledge among the final-year electrical engineering students in Universiti Teknologi Malaysia during the phase of problem identification?

2) What is the levels of Metacognitive Monitoring and Self-Regulation among the final-year electrical engineering students in Universiti Teknologi Malaysia during the phase of problem identification?

3) What is the level of Metacognitive Knowledge among the final-year electrical engineering students in Universiti Teknologi Malaysia during the phase of strategy development and the actual problem-solving process?

4) What is the levels of Metacognitive Monitoring and Self-Regulation among the final-year electrical engineering students in Universiti Teknologi Malaysia during the phase of strategy development and the actual problem solving process?

5) Is there any difference in metacognition level of the final-year electrical engineering students in Universiti Teknologi Malaysia during the phase of problem identification and the phase of strategy development and the actual problem-solving process?

6) Is there any relationship between Metacognitive Knowledge and Metacognitive Monitoring and Self-Regulation throughout the process of problem-solving in the problem-based laboratory among the final-year electrical engineering students in Universiti Teknologi Malaysia?

1.6 Research Hypotheses

The hypotheses of this study are as followed:

$H_0$1: There is no significant difference in metacognition level of the final-year electrical engineering students in Universiti Teknologi Malaysia during the phase of problem identification and the phase of strategy development and the actual problem-solving process.

$H_0$2: There is no significant relationship between Metacognitive Knowledge and Metacognitive Monitoring and Self-Regulation throughout the process of problem-solving in the problem-based laboratory among the final-year electrical engineering students in Universiti Teknologi Malaysia.

1.7 Theoretical Framework

This section will be emphasized on theories that is related to this study. Besides, this section demonstrates the relationships among the theories in spite of the problem-solving process among the final-year electrical engineering undergraduates after they have been assigned a task by the facilitators in the Problem-based Laboratory.

This study emphasized on the involvement of students' metacognition during solving problems. Metacognition is the complex order thinking. It encompasses the active control on the processes of cognition involves in learning. In other words, it is a way that the individuals are able to indicate their personal cognition. Flavell (1979) identified metacognition as students' awareness of their personal cognition about the cognitive phenomena.

Metacognition theory is developed by Flavell et al. (2002). They proposed that metacognition composed of the Metacognitive Knowledge and Metacognitive Monitoring and Self-Regulation. There are three elements included in the Metacognitive Knowledge, which are knowledge about persons, knowledge about tasks and knowledge about strategies. Knowledge about persons is referred to an individual's knowledge and belief about the human as cognitive processors. This includes the knowledge of personal cognitive features, cognitive variances among different individuals, and cognitive resemblance among all individuals. Knowledge about tasks is divided into two elements, which are the task information and demands in task completion. With the task information, it is about the information that an individual has to seek, such as the resources. The demands in task completion is about the demands of the task. While, the knowledge of strategies is about the knowledge of action which can be implemented to accomplish the task.

Whereas, the Metacognitive Monitoring and Self-Regulation consists of planning, monitoring, evaluating and self-regulation. Planning is defined as individual's capabilities to plan his or her task. It includes the choices of appropriate strategies and the implementation of resources which will have an impact on the performance of the individual (Schraw & Moshman, 1995). For instance, the allocation of the time, the appropriate resources to be utilized in the task, the steps in accomplishing the task, and the required strategies to reach the goals. Next, monitoring is about examining all the ideas and make comparison in obtaining the most appropriate answer, which involves the questioning about whether one doing well, the understanding of the questions and whether the answer is appropriate (Woolfolk, 2014). The evaluation is the process of judging the implementation of all the steps involved, progression and the consequence of learning. For example, the decision of whether to amend the strategies implemented. The Self-Regulation is examining the ideas and actions for successive cognitive activities, such as checking all the works done.

Constructivism suggested that students develop individual knowledge through the process of learning. Students build their knowledge of what they have learned by experiencing and the process of cognition (Bruner, 1960). Hence, learning is not merely memorizing, the most crucial is that through experiencing, the knowledge is being created (Woolfolk, 2014). Learning is an active process in which the students form new concepts or theories from the existing knowledge (Bruner, 1966). Social Constructivist Theory knowledge is built in a social situation and it is influenced by the collaborations with the group members or peers. The thought and speech are implemented to strengthen the students' communication with group members or peers (Vygotsky, 1896-1934). According to John (2012), Vygotsky developed the Zone of Proximal Development concept, which is that a child is able to tackle a problem with the help from the adult, teachers or peers that are more competent than them.

In respect to the cognitive psychology, learning is depended on the way individuals understand the world. Individuals' behaviour is affected by their thought of the world (Matlin, 2009). Biggs (1987) claimed that learners' current cognitive structures formed the knowledge. In contrast, learning is considered as the active finding procedure. Because the cognitive and social development are interdependent, student-centred learning is deemed to be the appropriate way to imply two of the theories, namely the cognitive psychology and the Constructivism theory. Students are active in learning and their critical thinking skills and problem-solving skills will be strengthened through student-centred learning (O'Neil & McMahon, 2005).

1.8 Conceptual Framework

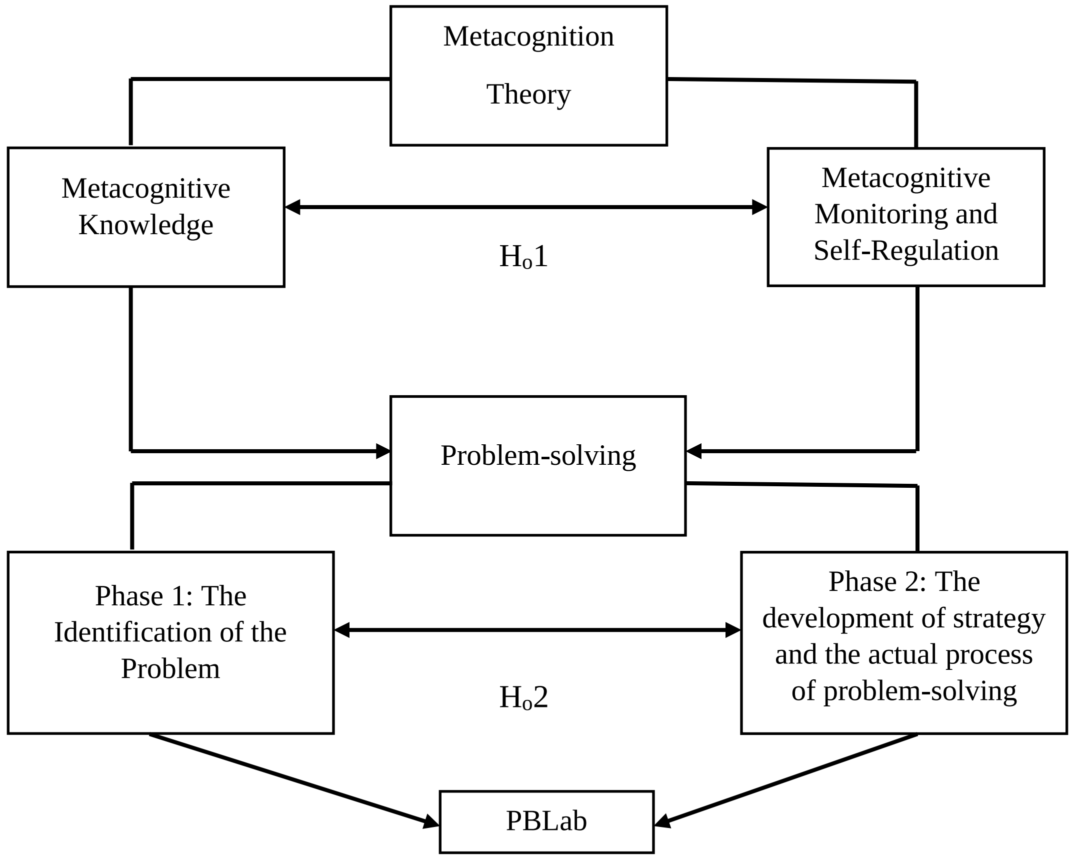

Figure 1.1: Conceptual Framework

This study is conducted to assess the metacognition level of the final-year electrical engineering undergraduates when they solve problem. Problem-solving is regarded to as one of the elements of the metacognition (Blummer & Kenton, 2014). In order to solve the problem easily, students need to possess higher-order thinking skills.

As refer to the conceptual framework above, the metacognition framework which is formed by Flavell et al. (2002) has been utilised. There are two main variables for the conceptual framework, one is the independent variable and the other is the dependent variable. Independent variable is variable that can affected the other variable, namely the dependent variable in a study (Flannelly et al., 2014). In the opposite, dependent variable is the variable that will response to the any changes made on the independent variable (Flannelly et al., 2014).

The independent variable in this study consists of two major elements, which are the Metacognitive Knowledge and Metacognitive Monitoring and Self-Regulation. Whilst the dependent variable is referred to the phases of problem-solving throughout the problem-based Laboratory, which composes of Phase 1: Problem Identification and Phase 2: Strategy Development and The Actual Problem-solving Process. In phase 1, the final-year electrical engineering undergraduates implemented Metacognitive Knowledge and Metacognitive Monitoring and Self-Regulation when their facilitator or lecturer assigns the task to them in identifying and understanding the problem of the assigned task.

The arrows demonstrated the results cause by the item stated in front. Hence, the problem-solving of the students through the two phases of problem-solving in the problem-based learning laboratory are presumed to be determined by the metacognition of the students.

The Metacognitive Knowledge can be classified into three categories, namely Knowledge of Persons, Knowledge of Tasks and Knowledge of Strategies. In Knowledge of Persons, the students know their own and classmates' cognition level. They can apply this in the problem-based learning lab. For instance, if a student intends to obtain more resources to be able to understand the problem assigned to him, he will go and find a book to refer to. However, as he knows that reading book is not his interest, he might choose to group with classmates who are good in reading book to solve the problem. Knowledge of Tasks which is referred to the information the students obtain from the task that they have to accomplish. Whereas, the Knowledge of Strategies is any methods that the students will apply in order to achieve this phase. Throughout this phase, students try to recall what they have learned before, related what they have learned into the task and have a better understanding of the problem.

While, with Metacognitive Monitoring and Self-Regulation, the students will go through the process of planning, monitoring, evaluation as well as self-regulation. In the first step, the students have to plan the time, venue for the group to meet up in order to divide the group tasks among the group members. In the next step, the students will show their works among the group members and do discussion about the problems they face in completing the tasks. In the last step, the students will assess their work by assessing their progress. Self-regulation is included in those three steps to give comment and assist for the continuous step's planning.

In the second phase of problem-solving, it composes of the development of strategy and the actual process of problem-solving. Students plan through using their metacognitions and implement strategies in solving the actual problem. The knowledge of persons in this phase is resemblance to the one in the first phase, which the knowledge of persons enables students to know about their metacognitions as well as of their classmates. For instance, if students know that they are not handful in performing the experiment, they might ask the other group members who are skilful, to be able to learn from them the way to develop strategies and conduct the experiments to solve the problem. Furthermore, the students can apply the Knowledge of Tasks which they have obtained from the first phase to strengthen the strategy and solve the actual problem. With the Knowledge of Strategies, students utilized knowledge e.g. concept or theories they have learnt before to solve the problem from the assigned task.

In respect of Metacognitive Monitoring and Self-Regulation, the first step is planning. The students have to plan on the development of the strategies. This includes the way the students handle the resources, time and strategies, e.g. The students might allocate the assigned tasks with their group members and comparing the facts among them. In the next step, students might examine their current performance as well as the following strategies by applying self-regulation methodology. For instance, students examine the steps of the tasks they perform by watching the demonstration video in Youtube. They also obtain the feedback from their facilitators. In the last step of the Metacognitive Monitoring and Self-Regulation, the metacognitive is evaluated through the results of the strategy and time consumption, responses of the facilitators, challenges of the software, development of strategies and time limit as well as students' feelings about themselves and the perception of their own weaknesses.

1.9 Significance of Study

Throughout this study, it will help the lecturers to obtain better comprehension of the metacognitive patterns which includes Metacognitive Knowledge and Metacognitive Monitoring and Self-Regulation of the final-year electrical engineering students throughout the four weeks' problem-based learning in problem-based laboratory at Digital Signal Processing Laboratory. Past studies suggested that students who possess metacognitive skills will have the ability to solve difficult problems, as they know how to solve the problems by applying the concepts or theories which they have learnt before (Tanner, 2012). This will have major influence on students' problem-solving skills as well as learning. Hence, this study is considered as important to expand the knowledge of the lecturers about the metacognitive patterns of the final-year electrical engineering students when they do problem-solving. With this, the lecturers will be able to develop and apply teaching and learning activities which can assist in improving or enhancing students' metacognitive thinking throughout the engineering course. In addition to this, lecturers are also able to understand each student's strengths and weaknesses of metacognition thinking in regard to the problem-based learning. Thus, lecturers can implement some activities which can specifically induce the metacognition thinking of the students.

By enhancing students' metacognition thinking in problem-solving throughout the engineering curriculum, it will also benefit the students themselves, which they are aware of them as the ones who are responsible to solve every problem present to them and they are the one who are taking in charge of their learning, not others, namely the lecturers or their friends. Notwithstanding with that, it assists the students in secure their employment in future workforce. This is due to current employers are more emphasized on employing those graduates who possess soft skills, one of them includes problem-solving skills, rather than employing graduates who only possess the hard skills.

1.10 Scope of Study

The focus of this study is on discovering the metacognitive level of the final-year electrical engineering students of Universiti Teknologi Malaysia in respect to Metacognitive Knowledge and Metacognitive Monitoring and Self-Regulation throughout the process of problem-solving in the problem-based laboratory which the students participated for four weeks in the two main phases, which includes the identification of problem and development of strategy as well as actual problem-solving process. The research will be quantitative as questionnaires will be applied for this study.

1.11 Limitations of Study

The samples of the study are final-year electrical engineering students who enrolled in Universiti Teknologi Malaysia (Johor Campus) during semester 2, academic session 2020/2021. They are also those who had gone through problem-based laboratory at Digital Signal Processing Laboratory for four weeks.

This study contains several limitations. Firstly, as the samples composed of Universiti Teknologi Malaysia's final-year electrical engineering students in Johor campus, the result cannot be generalized to other public universities in Malaysia, as the survey results might be different in terms of the teaching and learning styles of the universities. Secondly, the samples are surveyed through the questionnaire created using Google Docs and distributed through email or WhatsApp due to the Covid-19 crisis in

Malaysia, where the samples cannot be reached out face-to-face, the responses getting from the samples might not be accurate. This is because the respondents who do the survey might be those who are interested in doing survey, left out those who do not like to do survey. Fourthly, the samples respond were through purposive sampling, the responses might be similar. Thus, the samples might not be representative of all final-year electrical engineering students. Fifthly, the samples might answer the questions according to their perception of the metacognitive patterns in regard to the complex problem-solving. Hence, the results are strongly depending on the honesty of the respondents.

1.12 Definition of Terminology

To have a better understanding of this study, the following terms are defined in this research:

1.12.1 Metacognition and Metacognitive Level

Metacognition is defined as the knowledge and control of our cognition (Eggen & Kauchak, 2016). In this study, Metacognitive Knowledge and Metacognitive Monitoring and Self-Regulation's level which is developed by Flavell et al. (2002) will be measured to find out the cognition among the final-year electrical engineering undergraduates throughout the two phases of problem-solving, which are firstly, the identification of problem and secondly the process of solving actual problem. The Metacognitive Level can be differentiated into either low or high Metacognitive Level. Students with high metacognition level think more in the problem-solving process in contrast with students with low metacognition level who think less when solving the problem.

1.12.2 Metacognitive Knowledge and Metacognitive Monitoring and Self-Regulation

Metacognitive Knowledge is referred to as the thinking process of the students' perception, knowing about their own selves as well as the group members, the assigned tasks and strategies developed throughout problem-solving. Metacognitive Monitoring and Self-Regulation is the students' metacognition in implementing their thinking in problem-solving in regard to the Metacognitive Knowledge. Metacognitive Monitoring and Self-Regulation include planning, monitoring and evaluation (Flavell et al., 2002).

In the phase 1 of problem-solving which is the problem identification, students think of themselves as problem solvers. They think of the way to deal with the problem related to the student pack which comprises of microelectronics. While, with Metacognitive Monitoring and Self-Regulation students plan how to allocate the resources, time as well as strategies. Students are also aware of their planning by supervising throughout the process to make sure the progress is in line with the commenced planning.

In the phase 2 of problem-solving which is the development of strategy and the solving actual problem process. The knowledge and skills that students possess affected the students' belief of own selves. The knowledge of students on the given task were obtained from the knowledge they have learned before. Besides, students create awareness that they are able to solve the problem by implementing the appropriate solution as well as steps to the assigned tasks. In addition, they refer to other resources to make sure their strategies are correct. The students also gone through the process of trial and error. Whereas, with Metacognitive Monitoring and Self-Regulation in this phase, students solve the problem through the guidance from the facilitator, help from the peers, other resources which is accessible and also the management of time. The strategies developed were tested when the students manage the process of trial and error. Students also examine the process as well as the feedback from the facilitators. Students then assessed the tasks due to the outcomes, responses, tasks and their weaknesses as well as feelings upon themselves.

1.12.3 Problem-solving in Problem-based Laboratory

Problem-solving is when new responses are formulated further than the regulations that have learned earlier to reach the target (Woolfolk, 2014). Problem-solving activities that includes in the electrical engineering course includes gathering information, thinking strategically, metacognition and others, in order to generate and find a problem solution (Silver, 2013).

The process of problem-solving among the final-year electrical engineering graduates when they have the problem-based laboratory at the Digital Signal Processing laboratory in UTM. There are two phases of problem-solving involve in this study, which are the first phase: problem identification and the second phase: strategy development and solving actual problem.

1.12.4 Problem-based Laboratory

Problem-based Laboratory is a laboratory course that the undergraduate students who enrol in electrical engineering course in UTM are required to attend. Problem-based learning pedagogy is executed through this course. Students gain lots of advantages by attending this course, such as in their learning, as it involves the engagement of students in the experimental tasks which is resemblance to the real-world problems, in which the students are required to discover the answers by themselves.

Problem-based laboratory activities are conducted in various laboratories at the School of Electrical Engineering (SILE). The activities lasted for 14 weeks. Within those 14 weeks, students were placed into different groups for all the activities and facilitators assigned the tasks to the students. Students need to accomplish the task in the four weeks' time. Throughout the process, students are required to have discussions with their group members and assign the tasks among the group members. During the final week, the students need to hand in and do presentation on their project report.

1.13 Summary

This chapter includes background of study, problem statement, objectives of the study, research questions, research hypotheses, significance of the study, theoretical framework, conceptual framework, limitations of the study and the definitions of terms. The background of study outlines briefly about what the research will be discussed about. In the problem statement, it addresses several issues by highlighting existed research gap discovered in previous studies that requires further research through this study. The objectives of the study state the purpose of conducting this study. It leads to the generation of the research questions and research hypotheses that guides the route for this study. Several theories related to the topic of this study are illustrated via theoretical framework and conceptual framework. The advantages which will be received from this study are stated in the significance of the study, while the constraints of the study are indicated in the limitations of the study. Specific terms that will be utilised in this study will be explained in the definitions of terms. Lastly, summary is provided at the end of this chapter.

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