THE EFFECT OF INTEGRATING STEMPRENEUR 6E PROJECT-BASED MODULE IN ENHANCING LOWER SECONDARY SCHOOL STUDENTS' ENTREPRENEURIAL THINKING

HARTINI BINTI HASHIM

UNIVERSITI SAINS MALAYSIA

2022

THE EFFECT OF INTEGRATING STEMPRENEUR 6E PROJECT-BASED MODULE IN ENHANCING LOWER SECONDARY SCHOOL STUDENTS' ENTREPRENEURIAL THINKING

by

HARTINI BINTI HASHIM

Thesis submitted in partial fulfilment of the requirements
for the degree of
Doctor Philosophy

September 2022

ACKNOWLEDGEMENT

One of the most significant academic challenges experienced in this PhD journey has been the conduct of the research and the writing of the dissertation. Without continuous guidance and support from the people around me, it would surely be impossible to complete my research.

First of all, I would like to take this opportunity to express my greatest appreciation and millions of thanks to my supervisor, Dr. Mohd Norawi Ali, and my co-supervisor, Associate Prof. Dr. Ali Samsudin, for all their invaluable advice, guidance, encouragement, assistance, and concern given over time to allow me to complete this thesis. I would also like to extend my gratitude and thanks to all the lecturers for the workshops conducted at the University of Science Malaysia and the online webinars which greatly enhanced my knowledge of methodology and all related subjects.

My thanks and appreciations also go to YM Raja Anoro bin Raja Kob, the principal of the selected school, Kota Bharu, Kelantan, for his approval and cooperation rendered to me in conducting my research in his school. My special thanks go to a form-one science teacher, Tn Hj Nik Ismail bin Nik Ibrahim, for his willingness to participate in the intervention session.

Last but not least, I would like to extend my gratitude and appreciation to my parents, Haji Hashim Omar and Hajjah Habshah Ismail for all their support, guidance and relentless prayers. For the one who is always patient with me…my dearest love Tasadaq Hussain Khan, thank you so much. It would certainly have been a lonely journey in completing this study without them by my side.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF PICTURES

Page

LIST OF ABBREVIATIONS

6E	Engage, Explore, Explain, Engineering, Enrich and Evaluate
BSCS	Biological Science Curriculum Study
KSSM	*Kurikulum Standard Sekolah Menengah*
MANOVA	Multivariate Analysis of Variance
MOE	The Ministry of Education Malaysia
SPSS	The Statistical Package for Social Science
STEM	Science Technology Engineering and Mathematics

LIST OF APPENDICES

KESAN INTEGRASI MODUL STEMPRENEUR 6E BERASASKAN PROJEK UNTUK MENINGKATKAN PEMIKIRAN KEUSAHAWANAN PELAJAR SEKOLAH MENENGAH RENDAH

ABSTRAK

Kajian ini bertujuan untuk menganalisis kesan Modul STEMPRENEUR terhadap pemikiran keusahawanan pelajar menengah rendah. Lima teori yang terlibat dalam kajian ini; Teori Konstrutivisme, Teori Ketahanan, Teori Konstruktif Sosial Vgotsky, Kognitif Bruner, dan Teori Kolb. Walau bagaimanapun Teori Konstructivisme yang memayungi keempat-empat teori tersebut. Reka bentuk kajian adalah pre-ekperimen dengan pra-ujian, pasca-ujian, dan pasca-ujian II satu kumpulan diterapkan dalam kajian ini. Terdapat 44 pelajar dari Sekolah Menengah Kebangsaan Tingkatan Satu di Kota Bharu, Kelantan yang terlibat dalam kajian ini. Kajian ini melibatkan aktiviti luar dan program selepas sekolah dengan keizinan ibu bapa. Data dikumpulkan tiga kali, iaitu semasa pra-ujian, pasca-ujian dan pasca-ujian tertangguh dari borang soal selidik pemikiran keusahawanan. Hasil kajian MANOVA menunjukkan bahawa, Modul STEMPRENEUR memberi kesan positif kepada minda keusahawanan pelajar. Selain itu, wawancara pelajar, dan juga jurnal reflektif digunakan sebagai data kuantitatif sokongan. Kajian ini juga mendapati bahawa, minda keusahawanan dapat dikembangkan, dan pemupukannya hendaklah dimulakan pada tahap awal, iaitu dari peringkat sekolah rendah.

THE EFFECT OF INTEGRATING STEMPRENEUR 6E PROJECT-BASED MODULE IN ENHANCING LOWER SECONDARY SCHOOL STUDENTS' ENTREPRENEURIAL THINKING

ABSTRACT

The purpose of this study was to analyse the impact of STEMPRENEUR MODULE on the entrepreneurial mind of lower secondary students. Five theories were involved in this study; Theory of Constructvisme, Theory of Resilience, Vgotsky's Social Constructive Theory, Bruner's Cognitive, and Kolb's Theory. However, Theory of Constructivisme would be the umbrella for the others four theories. This research was conducted with a pre-experiment, where a one group pre-test, post-test, and post-test II design was applied. A total of 44 Form-One students from one of the secondary schools in Kota Bharu, Kelantan participated in the study, which involved outdoor activities and after-school programmes, conducted with their parents' permission. The data was collected three times, during the pre-test, post-test and post-test 2, from the distributed questionnaires; Entrepreneurial Mind. Besides, students' interviews, analysed photos and reflective journals were also used as supporting quantitative data. The findings of MANOVA revealed that, STEMPRENEUR Module brings a positive effect on students' entrepreneurial minds. The study also found that, a student's entrepreneurial mind can be developed, and its inculcation should start at a very early stage, namely from the primary school level.

CHAPTER 1

INTRODUCTION

1.1 Introduction

The needs of individuals who are well-equipped in their fields and who can make innovations out of their expertise have increased recently, due to the pulsating pace of development in science and technology. In fulfilling these needs, a good understanding of Science, Technology, Engineering, and Mathematics (STEM) disciplines among those with expert competencies in their fields are demanded, in tandem with the requirements of the 21st-century economics development.

Concerning this, there should be a platform for producing students who will become competent employees equipped with intellectual tools, which render them mentally flexible and intellectually disciplined. Realising the requirements of the Malaysian economy, which is based on information technology and services, in October 2011, the Ministry of Education launched a comprehensive review of the education system in Malaysia, to develop a new National Education Blueprint. Based on the findings of this review, the Malaysian Education Development Plan or PPPM (2013-2025) stated Science, Technology, Engineering, and Mathematics (STEM) to be one of the most important agenda to be put forward in education transformation (Ministry of Education, 2013). According to Havice (2009), the integration of these STEM subjects, in terms of theory and application, will develop students' soft skills. Moreover, Malaysia as an emerging economy, intends to be prepared and equipped for the Industrial Revolution 4.0 (I.R 4.0). This revolution has brought a global wave of change and has prompted Malaysia to keep up with this changing trend. Therefore, the development in education and industrial fields has seen the skills expand much

wider to include an entrepreneurial thinking. The I.R 4.0 reflects a new wave of technology in all aspects of business and industry. Thus, to compete in the 21st century, students must master a few soft skills, such as problem-solving skills, decision-making skills, critical thinking skills, creative thinking skills, and resilience (Soffel . J., 2016), apparently missing in our present education system (Aspen Youth Entrepreneurship Strategy Group, 2008; Zhao, 2012). Moreover, empirical evidence indicated that, students' thinking skills, especially critical thinking and creative thinking skills in Malaysian public institutions of secondary (Nagappan, 2000) and higher learning (Nagappan, 2010) were below the expected proficiency level.

Those skills are no longer limited only for the elites in a society to master, rather, they have become essential instruments to pump new ideas into the economy, revolutionise what our nation produces, and transform the way we produce them. Therefore, the requirements to develop new learners have to shift away from teaching the hard facts to teaching soft skills, such as developing an Entrepreneurial thinking survival skills for all of us (Wagner, 2008). Therefore, teachers and educators act as key players in producing the talent pool.

There are a few components in the Entrepreneurial thinking, such as critical thinking, creative thinking, creative problem solving, and decision making (Zhao, 2012), resilience, and searching for the opportunity (Davis et al., 2015; Ferrero & Fioro, 2014). However, in this study, entrepreneurial thinking consist of five components, which are, problem-solving skills, decision-making skills, critical thinking skills, creative thinking skills, and resilience, also determined as dependent variables. These skills are acknowledged as some of the accelerative skills in this changing era, well beyond the level of memorizing facts (Thomas & Thorne, 2019).

In all these skills, a deep-thinking process is involved, which includes critical and creative information processing when solving complex problems (Brookhart, 2010; Conklin & Manfro, 2012). As stated by Huang (2011), individuals do not only need to be educated, but they also need to possess the ability to think effectively and creatively, to make the right decisions to live well or even merely exist in this highly competitive world.

Moreover, in recent decades, the entrepreneurial thinking has become crucial in boosting the country's economic development which has a positive influence on our national economic growth. In developed countries such as America, entrepreneurs are the engine of job creation, generating millions of good jobs (Zhao, 2012).

Regarding this**,** STEM as an integrated approach in teaching science are able to engage students in activities, that involve the use of tools and manipulation of objects, where it helps them build social skills, as they actively engage in a team discussion, joint decision making, and collaborative problem-solving (Jolly, 2017).

Several groups who have been working on STEM integrated approach in teaching found that, one of the requirements for STEM classes or programmes is for students to work in groups to plan, design, and build prototypes and products, which they then test and evaluate, before deciding how to improve them (Jolly, 2017). Project Based Learning (PjBL) is an approach used in STEM classes or programmes to teach science. In Project Based Learning (PjBL), students focused on engaging in learning core ideas and practices of science and engineering (Krajick & Czerniak, 2014). This approach has been embedded with the 6E Learning byDeSIGN in the STEMPRENUR module, used during extracurricular and outdoor activities. In this module, students covered the density topic, in terms of its concept and the

applications, and they were exposed to experiential learning in their indoor and outdoor activities. The hands-on, discovery–based approach nurtures an entrepreneurial thinking, which reinforces the similarities and the links between the two. The real-world opportunities, where students are exposed to create and carry on a solution, are what ignite the entrepreneurial thinking (Root, 2017). The essence of entrepreneurial thinking cannot be found in a confined classroom, instead students need to connect with the outside world to understand, interact and communicate (Anamaria, 2019). Entrepreneurial thinking activities use mental abilities, such as understanding and solving problems and challenges (Holland, 2019). Experiential learning and skill development are two processes that are inextricably linked, where students actively participate in experiential learning to be able to meaningfully identify and reflect on their learning, a process that helps them develop new skills, new attitudes, and new ways of thinking (Education, 2016; Linda Lewis, 1994). As a result, students should be able to develop multiple skills necessary for competence, through experiential learning. STEMPRENEUR module is a typical strategy, currently used to develop those skills. The module represents an independent variable in this study. It could enhance students' entrepreneurial thinking in learning by doing activities, whereby two projects have been included, namely solar raft project and water level alarm project. Besides, it helps students and also teachers to find solutions to questions about the world around them, by allowing learners to develop an understanding of their ideas and engaging them in investigations to find solutions.

The 6E Teaching-Learning Model byDeSIGN which has been embedded in this project-based learning, consists of six phases, namely: (1) engage, (2) explore, (3) explain, (4) engineering, (5) enrichment, and (6) evaluate. Even though some other models can be used in STEM approaches such as 5E, the 6E has been chosen because

it consists of the engineering phase that can encourage students to think and to create, while guiding them through interdisciplinary and integrative learning and enabling them to gradually deepen their learning through hands-on processes and making products. This is comparably better than 5E Learning Cycles, which lacks an engineering element to effectively cultivate students' design ability.

1.2 Background

Rapid development has gradually caused many global environmental issues, such as environmental pollution, waste production, and disease spreading, which require a good problem solver, a good decision-maker, a critical and creative thinker, and last but not least a resilient man who is able to overcome the problems. Clearly, the problems of today's world are much more complex, and solving them requires the cooperation of many parties and individuals with good skills. However, a research had shown that, there is a global crisis related to this in education today, where students graduating from the secondary school level are exam-oriented, rendering them to tend to learn by memorization, thus depriving them of those important skills (Diaz & King, 2007). In Malaysia, the educational attainments, based on the Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA) results have been less than encouraging. Malaysia has been in the position of the bottom two-thirds, from the entire participating countries (Andrews et al., 2014). The results of the PISA 2009 also showed that, Malaysia ranked in the bottom third of 74 participating countries, below the International and Organisation for Economic Co-operation and Development (OECD) average. According to Martin et al. (2012), a total of 18% of Malaysian children have limited prerequisite knowledge and skills in science classroom, and 55% of them have limited prior

knowledge in science. This requires improvements of teaching methods by integrating the relevant subjects of Science, Technology, Engineering and Mathematics (STEM). In line with this, a research conducted by Henrisken (2014) suggests that, STEM integrated learning makes students' understanding more holistic, when using right brain and left brain. The results obtained from his research showed that, students became more creative, and they acquired critical thinking and abilities to solve problems, to communicate, and to collaborate with other related parties.

In the new global economy, problem-solving and decision-making skills have become a central issue for students nowadays, where in some instances, they are unable to neither reflect on the steps taken in the problem-solving and decision making processes, nor retain the skills and knowledge gained, or make connections between the processes and goals of solving problems. The application of a STEM interdisciplinary approach and STEM strategies, such as project-based learning and inquiry-based learning, in the form of 6E Teaching Modelling, as used in this study, can be applied simultaneously, in the integration of STEM. Therefore, STEM integration can be useful in the improvement of those skills required under entrepreneurial thinking among students, which will lead them to have better real-world connections in the curriculum (Brown et al., 2011)

Malaysia requires among others, scientists, technologists, engineers, and mathematicians, to become a developed country. Therefore, the Malaysia Education Development Plan 2015-2025 has outlined what well-qualified and high effective teachers need to effectively implement STEM subjects. STEM is an acronym for the study of or professional practice in broad areas of science, technology, engineering, and mathematics (Kamaleswaran et al., 2014). A professional teacher not only needs

to master knowledge discipline or knowledge content that will be conveyed to the students, but also the Pedagogical Content Knowledge (PCK), which will create a conducive and cheerful learning climate, while developing students' soft skills. One of the components in PCK is contextual knowledge (Ali et al., 2015). This knowledge should be identified and activated to create a 'resonance' effect by science educators, in their quest to make the learning environment meant to sustain students' interest and motivation towards science. Many science educators argue that, teaching should be carried out according to context and students' learning culture, so that, 'engagement' between the school and community takes place. The teacher's ability to comprehend students' background, as well as eliciting their cultural experience, language, and history i.e. funds of knowledge, will construct a learning climate that is livelier and engaging, besides establishing a two-way sharing between the student and the teacher (Ali et al., 2015). If the rich funds of knowledge in the students are integrated with the existing funds of knowledge of the science educators, the situation will be much more effective as a result of one complementing the other and vice versa.

Therefore, the main objectives in STEM are to get the students involved in active learning, by relating the lessons learned with the real world and aligning the curriculum with the industry and the required skills. In line with the STEM education definition, there are two key considerations of the activities in STEM, often referred to simply as science and technology (Petroski, 2010). Though Malaysia is directly comparable to the United States in the Science and Technology fields, the former consistently registers lower numbers of citizens who are interested in Science and Technology compared to the latter (MOSTI, 2008). Malaysia faced the same problem in getting students interested to learn science and technology as the United States, and the element of the entrepreneurship has been included as a cross-curriculum.

Meanwhile, entrepreneurship education has been emphasised in the the government enrolment policy to achieve a ratio of 60:40 for Science/Technical: Arts students, and this has brought a lot of changes in Malaysia Education. However, the number of students who have chosen STEM fields has continued to decline in recent year (Halim & Meerah, 2016). In our economic growth, creating job opportunities and social adjustment of the country make an entrepreneurial thinking an important role.

The STEM concept can be integrated into science teaching and learning by project, problem, and inquiry-based approaches (Kementerian Pendidikan Malaysia, 2016). However, recent studies suggested that, STEM is best integrated with project-based learning (Khairani, 2017; Sahin, 2015), as it can provide real-world learning experiences in science (Ayob et al., 2015; Kelly & Knowles, 2016; Laur, 2013) and enable students to work collaboratively, to solve challenging questions (Krajick & Czerniak, 2014). Besides, project-based learning is effective in increasing creativity (Ayob et al., 2015), critical thinking, problem-solving skills (Bell, 2010), and resilience, which will further develop entrepreneurial minds among students.

In this study, STEM was conducted in an extracurricular activity (ECA) during outdoor learning, because this is one of the ways to promote STEM to students out of the traditional classroom. Besides, there was another significant finding which pointed that, students enhanced their confidence and they were able to widen their learning knowledge, during extracurricular activities (Mtika, 2019).

1.3 Problem Statement

Entrepreneurial thinking is one of many skills that 21st century learners are required to have in facing an increasingly competitive world (Ahmad & Siew, 2021),

because it has the potential to enrich human capital in gaining innovative knowledge, new revolutionary ideas and strong ethical standards (Bacigalupo, Kampylis, Punie, & Van den Brande, 2016). Entrepreneur thinking is not an ability that needs to be mastered in order to become an entrepreneur, but it is a soft skill that is required to enhance human growth (Bacigalupo et al., 2016). However, integrating entrepreneurial thinking in learning is still not widespread (Ahmad & Siew, 2021). This was based on the PISA report 2018 (Schleicher, 2019), where the average score of Malaysian ninth graders, in terms of science literacy is only 438, below the international average score of 489. This has caused a great concern, since the nation holds high aspirations to achieve nation creators and become entrepreneurial community by 2030 (NEP 2022). Therefore, it is obvious that entrepreneurial thinking needs to be infused from a lower form level (Hoachlander & Yanofsky, 2011). In this study, the initiative was started with form one to develop students' entrepreneurial thinking. Entrepreneurial thinking in this study consists of problem-solving skills, decision making, critical thinking, creative thinking and resilience. As stated by Hunter et al. (2016), infused entrepreneurial thinking will encourage children to solve challenging and meaningful daily problems, as well as improving their cognitive reasoning skills. On top of that, entrepreneurial thinking opens up space for learners to think more broadly, to explore new ideas (English et al., 2017). Besides, students with entrepreneurial thinking are able to learn STEM, in real context, and develop their STEM literacy to succeed in the modern economic era (Tsupros et al., 2009). Entrepreneurial thinking also encourages students to improve science literacy (McDonald, 2016) and engineering skills, emphasised in STEM (Jin & Bierma, 2013).

Although entrepreneurial thinking has been introduced in the Malaysian curriculum, the module used by teachers to integrate entrepreneurial thinking among lower form school students is not widespread. Consequently, this study was carried out to improve the current practices of teaching and learning, so as to encourage entrepreneurial thinking among students. In moving forward, students must be versatile and entrepreneur thinking by having (1) problem-solving skills, (2) decision-making skills, (3) critical thinking skills, (4) creative thinking, and (5) resilience. With the current economic trends and changes that occur in the challenging world today, students should be equipped with skills and knowledge that shape them into effective and competitive individuals. The STEMPRENEUR module is based on 6E Instructional Teaching and Learning Model. 6E is an acronym for engage, explore, explain, engineering, enrich, and evaluate phases. According to Burke et al. (2014), each phase in 6E Instructional Model helps teachers to balance their teaching and students' knowledge, to have a better understanding of science skills and scientific knowledge. In this study, STEM project-based learning was conducted in the extracurricular period, after school, based on the 6E teaching model which consists of six phases, namely; (1) engagement, (2) exploration, (3) explanation, (4) engineering, (5) enrichment and (6) evaluation. Besides, teachers can also combine this model with various other teaching and learning strategies. However, in the STEMPERENUER module, 6E Instructional model is used, in combination with project-based learning.

The STEMPRENUER module was developed in Density and Buoyancy sub topic, in reference to the existing syllabus in Integrated Curriculum for Secondary School Science Form One, whereby science, technology, engineering, and mathematics are correlated and taught all together in the entire module. The prerequisite analysis conducted by the researcher regarding science teachers found out

that, Density and Buoyancy topic was the most difficult topic to be mastered by the students. Integrated Curriculum for Secondary School Science Form One suggested the project from Density and Buoyancy topic to be done by the students.

Thus, the STEM integrative approach in this study is an active learning approach that explores teaching and learning between Science and Mathematics subject in determining the density, with the aids of technology and engineering designs, which involved the construction of solar raft prototypes, as the first project, and water level alarm detector, as the second project. Science, as it is generally known, is full of wonderful ideas, that has the potential to change our perceptions and enrich our lives. Therefore, students should be encouraged to pursue their passion for science, learn more about it outside of classroom, and appreciate the beauty and meaning that come from applying science to new ways of understanding the world.

The activities involve indoor and outdoor learning. Even though a number of existing theoretical papers have linked outdoor learning with decision making, resilience, and creativity (Hattie et al., 1997), there is very little research on the combination of indoor and outdoor learning on the actual performance of entrepreneurial thinking. The integration of the 6E teaching model with the entrepreneurial thinking will be discussed in chapter two.

Studies show, that teacher-centred teaching and learning approaches often result in students lacking sufficient opportunities to be critical, creative and innovative (Ministry Of Education, 2013).

Furthermore, current teaching approaches are restricted in classroom lessons, without emphasis on extracurricular activities, while extracurricular activities and interests have been recognised to complement and enhance the classroom learning

process, to show changed student behaviour, and to shape students' attitudes (Azman, 2007). The capability of students to apply what they have learned in solving their daily life helps them to develop integrated meaningful understandings. Integrated understanding means that, ideas are connected in such a manner,that allows learners to be aware of and be able to use relationships between various ideas, to solve problems and understand the world they live in (Fortus & Krajcik, 2011). This will bring to a deep learning process, whereby the transformation process of learning can develop the essential skills and global competencies among the students.

Due to the response to this new world, the approach must change by focusing more on creating science, engineering, and develop students' soft skills. As stated by Vasquez et al. (2013), STEM education is an interdisciplinary approach to learning that removes the traditional barriers separating the four disciplines and integrates them into real-world, rigorous, and relevant learning experiences for students. These four fields form the core technological underpinnings of an advanced society.

It is time to stop asking students to solve the problems at the end of the chapter and instead, ask them to start taking a real role in finding answers to the questions that confront us. Concerning this, early exposure to students can cultivate and nurture the 21st-century skills that will lead them to become more creative and critical thinkers, good decision-makers, and problem solvers with an entrepreneurial thinking. The entrepreneurial thinking relates to how one's thinking or state of thinking or the lens, through which, one sees the world (Reed & Stoltz, 2011). However, a report from the Aspen Youth Entrepreneurship Strategy Group (2008) revealed that, an entrepreneurial thinking that emphasises a critical mix of success-oriented attitudes of the initiative, intelligent risk-taking, collaboration, and opportunity recognition is the

missing link. Now, unleashing entrepreneurial thinking of students, cultivating a mind-set of practice and creating environments in practice have become a part of educators' tasks. Thus, it is important to provide teachers with guidelines or science teaching strategies to promote the implementation of STEM in classrooms (Nur Diyana et al., 2016) for extracurricular to be used after school period. Therefore, there is a need to develop a STEMPRENEUR teaching module, based on the 6E teaching model, and to apply a project-based learning approach, which is expected to enhance the entrepreneurial thinking, among lower secondary school students.

1.4 Purpose of the Study

This research aimed to develop a STEMPRENEUR module, for use in extracurricular activities, in the development of Entrepreneurial Thinking (ET) among students of lower secondary school, and to study the impact of the module on the development of their entrepreneurial thinking. This research examined, in particular, the entrepreneurial thinking, that consists of five components, namely, (1) problem-solving skills, (2) decision-making skills, (3) creative thinking skills, (4) critical thinking skills, and (5) resilience.

1.5 Research Objectives

This research aimed to achieve its objectives as follows:

1. To develop a STEMPRENEUR module to be used in extracurricular activities by lower secondary students.
2. To determine the effectiveness of the STEMPRENEUR module in enhancing students' entrepreneurial thinking, which consists of problem-solving skills, decision-making skills, critical thinking skills, creative thinking skills, and

resilience, among lower secondary students, during extracurricular activities.

a) To determine the effectiveness of the STEMPRENEUR module in enhancing students' problem-solving skills concerning the following subscales:
    i. defining the problem
    ii. analysing the probable source of the problem.
b) To determine the effectiveness of the STEMPRENEUR module in enhancing students' decision-making skills, concerning the following subscales:
    i. choosing alternatives before making decisions
    ii. defining the risk because of the chosen alternative before making a decision.
c) To determine the effectiveness of the STEMPRENEUR module in enhancing students' critical thinking skills, concerning the following subscales:
    i. reasoning
    ii. gathering information
d) To determine the effectiveness of the STEMPRENEUR module in enhancing students' creative thinking skills, concerning the following subscales:
    i. curiosity
    ii. flexibility
e) To determine the effectiveness of the STEMPRENEUR module in enhancing students' resilience, concerning the following subscales:
    i. personal skills

ii. peers support

iii. social skills

3. To what extent the STEMPRENEUR module incorporated in the STEM Project-Based Learning (STEM PjBL) could enhance students' entrepreneurial thinking.

1.6 Research Questions (RQ)

Findings from this study should be able to answer all the questions below:

RQ1: How to develop the STEMPRENEUR MODULE to be incorporated in the STEM Project-Based Learning (PjBL) approach, during extracurricular activities?

RQ2: Is there any difference in the mean score of entrepreneurial thinking for Pre-test, Post-test, and Post-test II?

RQ 3a : Is there any difference in the mean score of Pre-test, Post-test, and Post-test II on Problem Solving skills, with respect to the following subscales:

i. defining the problem

ii. analysing the probable source of the problem.

RQ 3b: Is there any difference in the mean score of Pre-test, Post-test, and Post-test II on decision making skills, with respect to the following subscales:

i. choosing alternatives before making decisions

ii. defining the risk because of the chosen alternative before making a decision.

RQ 3c: Is there any difference in the mean score of Pre-test, Post-test, and Post-test II on critical thinking skills, with respect to following subscales:

i. reasoning

ii. gathering information

RQ 3d: Is there any difference in the mean score of Pre-test, Post-test, and Post-test II on creative thinking skills, with the respect to following subscales:

i. curiosity

ii. flexibility

RQ 3e: Is there any difference in the mean score of Pre-test, Post-test, and Post-test II on resilience, with the respect to following subscales:

i. personal skills

ii. peers support

iii. social skills.

RQ 4: To what extent could the STEMPRENEUR module incorporated in the STEM Project-Based Learning (STEM PjBL) enhance students' entrepreneurial thinking.

1.7 Research Hypothesis

Based on RQ2, sixteen hypotheses were developed, which could be tested, through a statistical analysis. The hypotheses utilised in this study are as follows:

***Ho 1*:** There will be no significant effect of STEMPRENUER module on the mean score of the entrepreneurial thinking, which consists of problem-solving skills, decision-making skills, critical thinking skills, creative thinking skills, and resilience, between Pre-test, Post-test, and Post-test II, among lower secondary students, during extracurricular activities.

Problem-solving skills, decision-making skills, critical thinking skills, creative thinking skills, and resilience are key constructs of the entrepreneurial thinking. Therefore, the next hypothesis is to perceive, if there is any difference between the mean score in the Pre-test, Post-test and Post-test II, for each of the major constructs of the entrepreneurial thinking.

- There is no significant main effect of entrepreneur thinking subscales
- There is no significant main effect of the test time.

Sub *Ho1*:

***Ho 1.1*:** There will be no significant difference in the mean score of the entrepreneurial thinking for problem-solving skills, between Pre-test, Post-test, and Post-test II.

Ho 1.2: There will be no significant difference in the mean score of the entrepreneurial thinking for decision-making skills, between Pre-test, Post-test, and Post-test II.

Ho 1.3: There will be no significant difference in the mean score of the entrepreneurial thinking for critical thinking skills, between Pre-test, Post-test, and Post-test II.

Ho 1.4: There will be no significant difference in the mean score of the entrepreneurial thinking for creative thinking skills, between Pre-test, Post-test, and Post-test II.

Ho 1.5: There will be no significant difference in the mean score of the entrepreneurial thinking for resilience, between Pre-test, Post-test, and Post-test II.

***Ho 2*:** There will be no significant effect of STEMPRENEUR module on the mean score of problem-solving skills, which consists of defining the problem and analysing the probable source of the problem, between Pre-test, Post-test, and Post-test II, among lower secondary students, during extracurricular activities.

Defining the problem and analysing the probable source of the problem is a sub-scale for constructs of the problem-solving skills, in the entrepreneurial thinking. Therefore, the next hypothesis is to see, if there is any difference between the mean score in the Pre-test, Post-test and Post-test II, for each sub-scale of problem-solving skills, in the entrepreneurial thinking.

- There is no significant main effect of the problem-solving skill subscales.
- There is no significant main effect of the test time.

Sub *Ho 2*:

***Ho 2.1*:** There will be no differences for the mean score of defining the problem, between Pre-test, Post-test, and Post-test II.

***Ho 2.2*:** There will be no differences for the mean score of analysing the probable source of the problem, between Pre-test, Post-test, and Post-test II.

***Ho 3*:** There will be no significant effect of STEMPRENEUR module on the mean score of the entrepreneurial thinking of decision-making skills, which consists of choosing alternatives, before making the decision and defining the risk because of the chosen alternative, before deciding, between Pre-test, Post-test, and Post-test II, among lower secondary students, during extracurricular activities.

Choosing an alternative before making decisions and defining the risk because of the chosen alternative before making a decision are sub-scale for constructs of the entrepreneurial thinking of decision-making skills. Therefore, the next hypothesis is to see, if there is any difference between the mean score in the Pre-test, Post-test, and Post-test II, for each of the sub-scale of entrepreneurial thinking for decision-making skills.

- There is no significant main effect of the decision-making skill subscales.
- There is no significant main effect of the test time

Sub *Ho 3*:

***Ho 3.1*:** There will be no differences in the mean score of choosing alternatives, before deciding, between Pre-test, Post-test, and Post-test II.

***Ho 3.2*:** There will be no differences for the mean score of defining the risk because of the chosen alternative, before deciding, between Pre-test, Post-test, and Post-test II.

***Ho 4*:** There will be no significant effect of STEMPRENEUR module on the mean score of the entrepreneurial thinking of critical thinking skills, which consists of reasoning and gathering the information between Pre-test, Post-test, and Post-test II, among lower secondary students, during extracurricular activities.

Reasoning and gathering the information are sub-scale for constructs of the entrepreneurial thinking of critical thinking skills. Therefore, the next hypothesis is to see, if there is any difference between the mean score in the Pre-test, Post-test and Post-test II, for each of the sub-scale of entrepreneurial thinking, for critical thinking skills.

- There is no significant main effect of the critical thinking skill subscales.
- There is no significant main effect of the test time

Sub *Ho 4*:

***Ho 4.1*:** There will be no differences for the mean score in reasoning, between Pre-test, Post-test, and Post-test II.

***Ho 4.2*:** There will be no differences for the mean score of gathering the information, between Pre-test, Post-test, and Post-test II.

***Ho 5*:** There will be no significant effect of STEMPRENEUR module on the mean score of the entrepreneurial thinking of creative thinking skills, which consists of curiosity and flexibility, between Pre-test, Post-test, and Post-test II, among lower secondary students, during extracurricular activities.

Curiosity and flexibility are sub-scale for constructs of the entrepreneurial thinking of creative thinking skills. Therefore, the next hypothesis is to see, if there is any difference between the mean score in the Pre-test, Post-test and Post-test II, for each of the sub-scale of entrepreneurial thinking for creative thinking skills.

- There is no significant main effect of the creative thinking skill subscales.
- There is no significant main effect of the test time

Sub *Ho 5*:

***Ho 5.1*:** There will be no differences for the mean score in curiosity, between Pre-test, Post-test, and Post-test II.

***Ho 5.2*:** There will be no differences for the mean score of flexibility, between Pre-test, Post-test, and Post-test II.

***Ho 6*:** There will be no significant effect of STEMPRENUER module on the mean score of the entrepreneurial thinking of resilience, which consists of personal skills,

peers support, and social skills, between Pre-test, Post-test, and Post-test II, among lower secondary students, during extracurricular activities.

Personal skills, peer support, and social skills are sub-scale for constructs of the entrepreneurial thinking of resilience. Therefore, the next hypothesis is to see, if there is any difference between the mean score in the Pre-test, Post-test and Post-test II, for each of the sub-scale of entrepreneurial thinking for resilience.

- There is no significant main effect of the resilience subscales.
- There is no significant main effect of the test time

Sub *Ho 6*:

***Ho 6.1*:** There will be no differences in the mean score in personal skills, between Pre-test, Post-test, and Post-test II.

***Ho 6.2*:** There will be no differences in the mean score of peer support, between Pre-test, Post-test, and Post-test II.

***Ho 6.3*:** There will be no differences in the mean score of social skills, between Pre-test, Post-test, and Post-test II.

1.8 Significance of the Study

The paradigm in instructional teaching and learning from teacher-centred to student-centred was an effect of STEM education. Project-based learning (PjBL) and presentation are a part of the STEM approach, that gives students a genuine learning experience, similar to a real-life experience. This module can be a reference for teachers, in developing their students' thinking skills.

The use of the STEMPRENEUR module with the 6E Teaching Learning model approach in this study was expected to help students in understanding the relevance and significance of their studies in their everyday lives and grasping the concepts learned, more accurately. Besides, the engineering phase included in the six phases is expected to be able to encourage problem-solving, decision making, creative thinking, critical thinking, and resilience among lower form students, since they need to design, create and test their project outcome at this phase. During the learning process, using the STEM approach, students were encouraged to create their questions, to enhance their thinking and analysing abilities.

Communications with classmates, teammates, and teachers are also encouraged, while presentation skills are enhanced, both being requirements for the students to excel in their future careers. Dialogue with peers becomes the vehicle, through which ideas are considered, shared, and developed, thus leading to a greater understanding of the topic of conversations. Students involved revealed that, working together in teams, to brainstorm, research, design, create, and develop prototypes to solve problems, really helped them (Jolly, 2017).

It is expected that this study will also help teachers to improve their students' performance in basic science and perhaps become the guideline for the Ministry of Malaysia Education in developing and enhancing inquiry-based science in the science curriculum.

Besides, the STEMPRENEUR module will contribute to the entrepreneur's thinking to 21st-century skills. Thus, the schools can plan and implement programmes to encourage the application of the recommended approach derived from the results of

this study, to promote environmental awareness towards the river, for example, by having a kayak programme, as included in this research.

1.9 Limitations

This study was carried out in one of the suburban secondary schools in Kota Bharu, which only has one Science class for form four and one Science class for form five, by begin the early exposure to form one students hopefully it can gain interest towards science among them at early stage. The samples of the study comprised a total of 44 form-one students. Even though the sample size was small, the findings are expected to contribute towards making science education more effective.

The contents of the module also need to be considered, since they were only based on density concepts and their application. Even though there were many topics in Science for lower form, topic density was chosen, because it involves calculations, with more applications in our daily life, and based on from previous literature, students always faced misconceptions in this topic. Besides, there were only to two projects undertaken in this study, due to time constraints, although the effects on the dependent variables could still be measured.

1.10 Operational Definitions

1.10.1 STEM Education

STEM is an acronym for Science Technology Engineering and Mathematics; disciplines of knowledge consisting of Science (Physics, Chemistry, and Biology) and Mathematics, with the integration of various technologies and engineering. STEM incorporates all the technologies, that engage Science and Mathematics (National

STEM Movement, 2016). STEM integration serves as a medium for developing 21st century skills, through subject content. A STEM interdisciplinary approach, as well as STEM teaching and learning methods, such as project-based learning and inquiry-based learning, can be used concurrently in STEM integration. It is an active learning approach that explores teaching and learning, between science and mathematics, in determining the density, with the aids of technology and engineering designs, that involved the construction of solar raft prototypes, and also a water level alarm detector. By constructing the solar raft prototypes and the water level alarm detector, students were able to have a better understanding of technology. Their inventions to make life easier and better enable them be aware of the technological world they live in; how technology, science and mathematics support each other; how to learn to use new technologies, as they become available; and how the technological decisions we make impact our lives and the lives of others (Vasquez et al., 2013). There are several different meanings of active learning, as commonly used in the field of education. However, Felder and Brent (2016) have established that, active learning is something relevant to the course that students in a class session are called on to do, rather than just watching and listening to a lecture and taking notes.

1.10.2 STEMPRENEUR Module

In efforts to produce high-quality and excellent young people who can survive and compete in the increasing competitiveness of science and technology, the training module is considered feasible to help students improve and develop their skills in entrepreneurial thinking. In this module, several activities were combined, completed, and related to each activity. By using Sidek's Model as instructional design in this STEMPRENEUR module, the density and buoyancy concept was emphasised. This