THE EVALUATION OF DEVELOPING A STEM PROGRAMME ON LOW-PERFORMING SECONDARY STUDENTS' BEHAVIOURAL INTENTION IN LEARNING SCIENCE

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SULTAN IDRIS EDUCATION UNIVERSITY

2022

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ABSTRACT

The purpose of the study was to develop a STEM programme in learning science for low performing secondary students. The STEM programme was developed based on the design principles (integration of current national curriculum, application in daily life using STEM practices, application of educational technologies, active learning, guidelines for future study and career pathways) in Design-Based Research (DBR) with three iterative cycles and refinements. The study was aimed to determine the impact of the STEM programme on low-performing secondary students' behavioural intention in performing STEM practices in learning science as well as students' perceived vocational choices. Explanatory sequential mixed methods design and quasi-experimental survey design were employed with the application of the pre-survey and post-survey approach. A simple random sampling technique was used to opt for two secondary schools in the Perak state. Experimental group involved 37 students who participated in the STEM programme while the comparison group involved 31 students. The research instruments used for quantitative data included closed-ended survey questionnaires while qualitative data were obtained through open-ended survey questionnaires, observational checklist and interview. The data were analysed by using non-parametric test, the Mann-Whitney test and Wilcoxon signed-rank test. The findings demonstrated there was a significant difference between the experimental group and the comparison group in the post-survey for the construct of attitude in the application of STEM practices (p=0.001) with moderate effect (d=0.821). However, there was no significant difference on the construct of perceived behavioural control, subjective norm, perceived usefulness, perceived ease of use and behavioural intention for experimental group. The overall Holland code for experimental group perceived vocational choices was Realistic, Artistic, Social (RAS) or Realistic, Social and Artistic (RSA). In conclusion, the developed STEM programme has improved low achievers' attitude in learning science and students' interest in Realistic careers. The study implicates the implementation of STEM programme encourages the application of STEM practices in the formal setting and outdoor learning that corresponding to students' learning standard.

PENILAIAN PEMBANGUNAN PROGRAM STEM TERHADAP NIAT TINGKAH LAKU PELAJAR MENENGAH BERPRESTASI RENDAH DALAM PEMBELAJARAN SAINS

ABSTRAK

Kajian ini bertujuan untuk membangunkan program STEM dalam pembelajaran sains untuk pelajar menengah berprestasi rendah. Program STEM telah dibangunkan berdasarkan prinsip reka bentuk (integrasi kurikulum kebangsaan semasa, aplikasi amalan STEM dalam kehidupan seharian, penerapan teknologi pendidikan, pembelajaran aktif, panduan untuk hala tuju pembelajaran dan kerjaya masa depan) dalam penyelidikan berasaskan reka bentuk (DBR) dengan tiga kitaran berulang dan pemurnian. Kajian ini bertujuan untuk mengkaji kesan program STEM terhadap niat tingkah laku pelajar menengah berprestasi rendah bagi pelaksanaan amalan STEM dalam pembelajaran sains serta pilihan vokasional pelajar. Reka bentuk kaedah gabungan penerokaan berurutan dan reka bentuk tinjauan kuasi eksperimen digunakan dengan mengaplikasikan pendekatan pra-soal selidik dan pasca-soal selidik. Teknik pensampelan rawak mudah telah digunakan untuk memilih dua sekolah menengah di negeri Perak. Kumpulan eksperimen melibatkan 37 orang pelajar yang menyertai program STEM manakala kumpulan perbandingan melibatkan 31 orang pelajar. Instrumen kajian yang digunakan untuk pengumpulan data kuantitatif ialah soal selidik tinjauan tertutup manakala data kualitatif telah dikumpul melalui soal selidik tinjauan terbuka, senarai semak pemerhatian dan temu bual. Data kajian telah dianalisis menggunakan ujian bukan parametrik, iaitu ujian Mann-Whitney dan ujian pangkat Wilcoxon. Dapatan kajian menunjukkan bahawa terdapat perbezaan yang signifikan dalam pasca-soal selidik antara kumpulan eksperimen dan kumpulan perbandingan dalam sikap pelajar untuk mengaplikasikan amalan STEM dalam pembelajaran (p=0.001) dengan saiz kesan yang sederhana (d=0.821). Walau bagaimanapun, tiada perbezaan yang signifikan dalam persepsi kawalan tingkah laku, norma subjektif, persepsi kebolehgunaan, persepsi mudah penggunaan, dan niat perilaku pelajar. Kod Holland kesuluruhan untuk pilihan vokasional kumpulan eksperimen ialah Realistik, Artistik, Sosial (RAS) atau Realistik, Sosial dan Artistik (RSA). Kesimpulannya, program STEM yang dibangunkan telah meningkatkan sikap pelajar yang berpencapaian rendah dalam pembelajaran sains dan minat pelajar terhadap kerjaya Realistik. Implikasi kajian menunjukkan pelaksanaan program STEM menggalakkan aplikasi amalan STEM di dalam suasana formal serta di luar bilik darjah yang bersesuaian dengan standard pembelajaran pelajar.

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LIST OF ABBREVIATIONS

ADTEC	Advance Technology Training Centres
Apps	Mobile Application Software
AR	Augmented Reality
C-TAM-TPB	Combined TAM and TPB
CVI	Content Validity Index
DBR	Design-Based Research
DDR	Design and Development Research Approach
EPPI	Evidence for Policy and Practice Information and Co-ordinating
EPRD	Educational Planning and Research Division
ICT	Information and Communication Technology
I-CVI	Item-level Content Validity Index
ILJTM	*Institusi Latihan Jabatan Tenaga Manusia*
ILP	*Institut Latihan Perindustrian*
ISD	Instructional System Design
IT	Information Technology
JMTI	Japan-Malaysia Technical Institute
JPN	*Jabatan Pendidikan Negeri*
KR-20	Kuder–Richardson Formula 20
MITI	Ministry of International Trade and Industry
MOE	Ministry of Education
MOHE	Ministry of Higher Education

NGSS	Next Generation Science Standards
NRC	National Research Council
NSES	National Science Education Standards
NSF	National Science Foundation
PISA	Programme for International Student Assessment
PPD	*Pejabat Pendidikan Daerah*
QDA	Qualitative Data Analysis
RACER	Research Acculturation of Early Career Researchers
RIASEC	Realistic, Investigative, Artistic, Social, Enterprising, Conventional
S-CVI	Scale-level Content Validity Index
SDS	Self-Directed Search
SMK	*Sekolah Menengah Kebangsaan*
SPM	*Sijil Pelajaran Malaysia*
SPSS	Statistical Package for the Social Sciences
STEM	Science, Technology, Engineering and Mathematics
TAM	Technology Acceptance Model
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
TVET	Technical Vocational Education and Training
UPSI	*Universiti Pendidikan Sultan Idris*
VR	Virtual Reality
WiFi	Wireless Fidelity

APPENDIX LIST

CHAPTER 1

INTRODUCTION

1.1 Introduction

The emphasis on Science, Technology, Engineering and Mathematics (STEM) education has been gaining traction all over the world and the innovation that arises from STEM fields pervade in every aspect of our daily life. The demand for technology in this modern world has induced the young generation to equip themselves with knowledge, skills and values as well as cultivate STEM practices. The Ministry of Education (MOE) has taken measures by reinforcing the quality of STEM education through the Malaysia Education Blueprint 2013-2025 to address the skill gaps among students (MOE, 2013). High-level analysis, learning content related to everyday life, expanded instructional time, practical implementation of knowledge by experimental and project-based activities have been specifically highlighted in science learning (MOE, 2013). School teachers are highly encouraged to develop STEM activities and embed STEM practices into every subject for preparing students to face 21st century challenges.

The nation has striven to ensure there are sufficient qualified to venture into the field of STEM at the tertiary level. Many students who graduated as O-Level qualification or *Sijil Pelajaran Malaysia* (SPM) school-leavers will take tertiary education as their first choice considering that high education qualification is the prerequisite to be successful in life with higher income. According to the data provided by the Ministry of Education, many parents and students are unaware of the vocational pathway and the respective career opportunities (MOE, 2013). In fact, weak and intermediate learners in academic have an alternative option to be high-skilled and educated workers by pursuing their studies and training at technical school, Industrial Training Institutes or *Institut Latihan Perindustrian* (ILP), Advance Technology Training Centres (ADTEC), Japan-Malaysia Technical Institut (JMTI) under Manpower Department Training Institute or *Institusi Latihan Jabatan Tenaga Manusia* (ILJTM).

Technical Vocational Education and Training (TVET) offers a wide variety of programmes in many areas, including architecture, art and design, communication, engineering science, computer and information technology. TVET students who are equipped with the knowledge and specific skills from hands-on training are more ready for the future workforce. Additionally, the current vocational curriculum at school has been enhanced and integrated with STEM subjects such as science technology and mathematics technology as their general core courses. The integration of STEM and TVET have demonstrated promising outcomes at the secondary school level as this will facilitate students' ability to construct linkage between STEM and TVET disciplines (Dixon & Hutton, 2016). As stated in Malaysia Budget 2020, the allocation used for TVET increased from RM 5.7 billion in 2019 to RM 5.9 billion in 2020 (Lim, 2018). The government resuming the initiative by allocating RM 6 billion to strengthen the TVET programme in 2021 (Aziz, 2020). The increasing amount of the allocation implied the government had viewed the potential of TVET as crucial to fulfil the needs of labour market and national economy.

As our country is still facing a significant shortage of high-skilled labour with required talents and knowledge, the cultivation of STEM practices should be strongly promoted at secondary school level to encourage students to develop their skills and apply it in the future career. According to the study, Malaysia has only 25 per cent of highly qualified workers, whereas Malaysia needs advanced Information and Communication Technology (ICT) infrastructure and research (Ramlee, 2017). The existing trainers may lack of creativity and unable to keep pace with the progress in technology are seen as a significant obstacle for the nation by Ministry of International Trade and Industry, MITI (2018). Therefore, in line with the government initiatives to produce more graduates with fine qualities from the skills training program, educators should initiate the first move in supporting students especially low-achievers to explore the world of industrial training with the use of STEM practices as proposed in this study.

1.2 Research Background

Low-performing students can be identified as students who scored below an expected standard on the examination of those grounds from the individual, family, social or environmental factors (Al-Zoubi & Younes, 2015). Our society often view students with low academic performance as culprits that tend to contribute to juvenile delinquency such as violence (Lepore & Kliewer, 2013) and drug use (Banerjee, 2016; Tobler, Komro, Dabroski, Aveyard, & Markham, 2011). As a first move to shift the change, it is important to understand several underlying factors that limit the students' educational attainment. These factors ascribed to teachers, students, parents and the school environments that essentially responsible for the low-performing students. Students with poor achievement scores might relate to low socioeconomic status (Banerjee, 2016; Lepore & Kliewer, 2013), deficiency of positive attitudes towards learning (Chen, Huang, & Chou, 2016b) with reduction of accommodating schools and teacher. Underachieving students are more likely to come from low-education family backgrounds or unemployed parents who are partaking in fewer academic engagements with their children (Banerjee, 2016).

Nowadays, youth spend most of their time in school, this socialisation mediator brings a substantial influence to students' behaviour. It is proven that value-added school demonstrated lower incidence of delinquent behaviours compared to school with poorer academic results (Tobler et al., 2011). Low-performing students are more likely to create discipline issues such as truancy because of the low expectation of accomplishment in addition to negative feedback from teachers and the concern of degradation in school (Banerjee, 2016). Underperforming students normally feel frustrated with the academic failure where they started to show passive attitude in attempting learning objectives. Furthermore, the challenges for teachers to address the needs of students with low academic achievement are still present in the current education scenario. This situation has an indirect effect on the manpower supply in our prospective nation development.

As a solution, strengthening STEM initiative has been advocated to upsurge students' participation and students' interest. However, numerous concerns in STEM lesson such as lack of understanding of the importance of STEM, perceived challenge of STEM subjects, content-heavy curriculum, exam-oriented education, teacher-centered learning approaches and limited laboratory equipment have led to the reducing interest and enrolment among students despite the declining quality and quantity of STEM graduates (MITI, 2018). For instance, based on the issues mentioned in National Policy on Industry 4.0, the school syllabus and pedagogy for STEM-related topics are uninteresting and do not correspond with industry needs (MITI, 2018). In the school setting, the STEM approach usually applies on students with high academic performance but not for low achievers as teachers assume this might be challenging for low achievers with little prior knowledge to solve real-world problems. A study of Banerjee (2016) mentioned that poorer grades make low-performing students unreachable for many high-profile classes such as professional in STEM field.

Subsequently, educators should provide equal opportunity to all the students regardless of their academic achievement to acquire STEM learning or skills. Findings have pointed out employer-desired STEM skills and knowledge are also essential for "non-STEM" occupations (Grinis, 2017). STEM skills are beneficial to students in daily life and future profession especially for those who pursue a TVET career that involved an advanced level of problem-solving. This allows students to have more options to achieve their career aspiration. Undoubtedly, it is obligatory to raise awareness and train the acquired skills among low-performing students at the secondary school to fulfil the demands in the potential work field.

1.3 Problem Statement

The passive behaviour of underachievers often linked to some personal issues like unsatisfactory basic knowledge, depleted motivation (Kuo, Tuan, & Chin, 2019), self-efficacy and self-regulation that deter the learning process (Chen et al., 2016b). Low motivation might result from the previous learning experiences while students struggle with a specific subject in traditional lectures as they lack of prerequisite knowledge. This category of students exhibited lower learning enthusiasm towards science which make them feel more problematic in fulfilling the task given (Lin, Fan, & Xie, 2020; Wu, Tuan, Hsieh, & Chin, 2013). Normally, low performers who are uninterested, unwilling to participate in group discussions, late for assignments and fail in academic are probably experiencing learning helplessness (Peterson, 2010).

Low-performing students in general are not qualified for special education, hence, school teacher possess the crucial obligation for their education. Regrettably, educational institutions have a tendency to concentrate on high achievers and neglect low achievers as they have minimal potential to attain academic distinction. School administrators and educators often lower their expectations and even reducing the curriculum context for low-performing students (OECD, 2016).

In addition, researchers often focus on average students especially high achievers as students with better academic performance who are more interested and more likely to pursue STEM career (Christensen, Knezek, & Tyler-Wood, 2015; Stoeger, Greindl, Kuhlmann, & Balestrini, 2017). Conversely, there are no recent studies to examine the engagement of underachievement students in STEM practice which is significant in science learning particularly in Malaysia. Thus, research is needed to develop an innovative STEM programme to overcome the aforesaid issue in science education for low-performing students.

The present exam-oriented curriculum is lead to a rushing situation due to the limited time of the lesson. In addition, most schools are facing financial constraint in buying the latest and expensive laboratory equipment (Radzi, Ghani, Siraj, & Afshari, 2018). These hindrances discourage science teachers to conduct time-consuming experiment (Salehi & Salehi, 2012; Singh & Muniandi, 2012). As a result, teachers usually opt for a time-saver method by verbally brief the experiment (Sumintono, 2015) and request students to memorise the concept (Yasin, Bashah, Yanti, & Basri, 2016) without allowing students to undergo the real practical activities or laboratory experiment. The conventional teaching method is contradicted with the goals of science education stated in the Framework for K-12 Science Education by National Research Council, NRC (2012). This disappointing situation is more likely to happen among poor academic performance students with low motivation and skills.

In fact, low-performing students perceived learning science in a more authentic way as they prefer inquiry-based learning that involved hands-on activities (Kuo et al., 2019). A study of Lin et al. (2020) proved that majority of the underachievement students favoured innovative learning activities. Hands-on experiment plays a crucial role in science learning to engage students in the discovery of new knowledge and development of scientific thinking. Underperforming students should be given the opportunity to carry out the laboratory work since inquiry-based learning is easier or more suitable for low achievers to comprehend the nature of science (Kuo et al., 2019).

Physics is the most suitable subject to demonstrate an engineering component due to the mutual fit of physics and engineering in the school curriculum. However, the engineering discipline is given the least attention in Malaysia (Bunyamin & Finley, 2016). There were no specific engineering courses established in curriculum for secondary level education. In fact, the engineering activity is sufficient to increase students' understanding of the science-related career (Ward, Lyden, Fitzallen, & León de la Barra, 2015) which is very relevant to this study. Most of the recent studies that focus on the engineering field were conducted in overseas (Asghar, Huang, Elliott, & Skelling, 2019; Sabo, Burrows, & Childers, 2014; Serrano Pérez & Juárez López, 2019; Ward et al., 2015). These studies share a common similarity which involved the intervention of STEM programme on middle school and high school students. Therefore, more studies that focus on physics topic are needed to be conducted on local secondary school students via STEM activities implementation.

In the process of learning science, the majority of students have difficulties in understanding the fundamental ideas especially those abstract physics concepts that involved time and space which are hard to be visualised. In this study, the relevant physics concepts included sound, force and motion as well as nuclear energy. For instance, the study of Okur and Artun (2016) summarised secondary students often have misconceptions on sound propagates in space and it propagates best in gas. Students also confused the high and low pitches of sound are the intensity of sound.

Besides, students faced difficulties in learning mechanics that involved force and motion such as lack of understanding about the free-body diagram, incompetent application of content knowledge and incomprehension of content knowledge (Zhou & Xiao, 2018). Students tend to make errors and develop misconception due to the deficiency of spatial ability to understand the plane motion in mechanics (Proulx, Romero, & Arnab, 2017). Systematic errors and random errors commonly occurred while conducting the linear motion experiment by using ticker-tape. Inaccurate experimental data obtained will lead to confusion and misunderstanding among students. High percentage of errors from experiment reported by students in the topic of sound and motion can be reduced via the innovative use of smartphones as experimental tools (Tho, Lee, & Baharom, 2018; Tho & Yeung, 2014).

Another topic specified in the Form 4 school syllabus is nuclear energy, which is difficult to perform experiments in a school laboratory. Most of the students have pessimistic views on nuclear radiation and concerns about nuclear safety (Brown, 2018). Moreover, students did not have any educational experience for the nuclear reactor site visit to understand the relevant facts such as the pros and cons of nuclear energy. The insufficient knowledge about nuclear energy should be addressed through the STEM programme implementation. Therefore, the topics focused in the STEM programme included sound, force and motion as well as nuclear energy to assist low-performing students in learning science.

On the other hand, smartphones with various built-in sensors can be applied as experimental tools for science learning (Hochberg, Kuhn, & Müller, 2018; Tho et al., 2018). The study verified that mobile device is an effective tool to induce learner's motivation, strengthening learner's participation and convey information (Sung, Chang, & Liu, 2015). Henceforth, this study aimed to design a STEM programme with the integration of guided STEM practices and innovative educational technology for low-performing students to improve their behavioural intention and learning attitude in learning science.

Subsequently, underperforming students are probable to confront more decision-making hindrances after completion of studies (OECD, 2016). Students with poor academic achievement are more likely to pursue TVET to become skilled technical professionals (Lam & Hassan, 2018). In spite of this, many students are still not aware of the potential of vocational pathway and the benefits in choosing local vocational training. Most individuals have a pessimistic view towards TVET as they presume that vocational training was allocated for low achievers or failures (Ramlee, 2017; Lam & Hassan, 2018). As a matter of fact, TVET and STEM are expected to be the key employment in the future global economic trends (Bakar & Mahmud, 2020). There is a need to put more emphasis on STEM practices among underachievers to prepare students to meet the demands for the future workforce. STEM skills remain essential in the future even though the student opts for a career out of the STEM profession. Thus, this study aimed to assist low-performing secondary students to understand their perceived vocational choices by establishing students' awareness on vocational pathway through ILP virtual tour and promote the cultivation of STEM practices into real-life application.

Furthermore, empirical studies that utilised Technology Acceptance Model (TAM) survey (Casey, Pennington & Mireles, 2020; Mater et al., 2020; Mutambara & Bayaga, 2020) mostly focus on behavioural intention towards educational technology in STEM learning but none of the research examines students' behavioural intention towards STEM practices that promote meaningful learning and embed knowledge profoundly into students' experience. As underachievers exhibited low enthusiasm in studying science (Lin et al., 2020; Wu et al., 2013), this research intended to investigate students' behavioural intention towards the STEM practices introduced via the STEM programme developed. The current study examined the relationship between perceived usefulness, perceived ease of use, attitude, subjective norm, perceived behavioural control with students' behavioural intention according to TAM and Theory of Planned Behaviour (TPB). The STEM practices are important as a guide for all the students to engage in scientific investigation, assist students to comprehend the ideas and create more meaningful knowledge (NRC, 2012). Hereafter, this research proposed a more comprehensive investigation on the relationship of subjective norm, perceived behavioural control, attitude, perceived usefulness, perceived ease of use with the behavioural intention of low-performing students.

1.4 Objectives of the Study

The research objectives of the study:

1. To develop a STEM programme with the application of STEM practices in learning science for low performing secondary students.
2. To determine the impact of a STEM programme on low-performing secondary students' behavioural intention in performing STEM practices in learning science.
3. To identify low-performing secondary students' perceived vocational choices.
4. To examine the relationship between low-performing secondary students' perceived ease of use towards the application of STEM practices in learning science with perceived usefulness through the implementation of a STEM programme.
5. To analyse the relationship of low-performing secondary students' perceived usefulness and perceived ease of use towards the application of STEM practices in learning science with attitude through the implementation of a STEM programme.
6. To analyse the relationship between low-performing secondary students' behavioural intention to apply STEM practices in learning science with selected factors such as perceived behavioural control, subjective norm, perceived usefulness, perceived ease of use and attitude through the implementation of a STEM programme.

1.5 Research Questions

The research questions of the study:

1. Is the developed STEM programme valid?
2. Is there any significant impact of the STEM programme on low-performing secondary students' behavioural intention in performing STEM practices in learning science?
3. What are low-performing secondary students' perceived vocational choices?
4. Is there a significant relationship between low-performing secondary students' perceived ease of use towards the application of STEM practices in learning science with perceived usefulness through the implementation of a STEM programme?

5. Is there a significant relationship between low-performing secondary students' perceived usefulness and perceived ease of use towards the application of STEM practices in learning science with attitude through the implementation of a STEM programme?
    a. Is there a significant relationship between low-performing secondary students' perceived usefulness towards the application of STEM practices in learning science with attitude through the implementation of a STEM programme?
    b. Is there a significant relationship between low-performing secondary students' perceived ease of use towards the application of STEM practices in learning science with attitude through the implementation of a STEM programme?

6. Is there a significant relationship between low-performing secondary students' behavioural intention to apply STEM practices in learning science with selected factors such as their perceived behavioural control, subjective norm, perceived usefulness, perceived ease of use and attitude through the implementation of a STEM programme?
   a. Is there a significant relationship between low-performing secondary students' behavioural intention to apply STEM practices in learning science with their perceived behavioural control through the implementation of a STEM programme?
   b. Is there a significant relationship between low-performing secondary students' behavioural intention to apply STEM practices in learning science with their subjective norm through the implementation of a STEM programme?
   c. Is there a significant relationship between low-performing secondary students' behavioural intention to apply STEM practices in learning science with their perceived usefulness through the implementation of a STEM programme?
   d. Is there a significant relationship between low-performing secondary students' behavioural intention to apply STEM practices in learning science with their perceived ease of use through the implementation of a STEM programme?
   e. Is there a significant relationship between low-performing secondary students' behavioural intention to apply STEM practices in learning science with their attitude through the implementation of a STEM programme?

1.6 Research Hypotheses

The research hypotheses identified to be tested:

H_{01}: There is no significant difference of behavioural intention in performing STEM practices in learning science between pre-survey and post-survey of experimental group students. (To answer research question 2)

H_{02}: There is no significant difference of behavioural intention in learning science between pre-survey and post-survey of comparison group students. (To answer research question 2)

H_{03}: There is no significant difference of behavioural intention in learning science between pre-survey of experimental group and comparison group students. (To answer research question 2)

H_{04}: There is no significant difference of behavioural intention in learning science between post-survey of experimental group and comparison group students. (To answer research question 2)

H_{05}: There is no significant relationship between low-performing secondary students' perceived ease of use towards the application of STEM practices in learning science with perceived usefulness through the implementation of a STEM programme. (To answer research question 4)

H_{06}: There is no significant relationship between low-performing secondary students' perceived usefulness towards the application of STEM practices in learning science with attitude through the implementation of a STEM programme. (To answer research question 5a)

H_{07}: There is no significant relationship between low-performing secondary students' perceived ease of use towards the application of STEM practices in learning science with attitude through the implementation of a STEM programme. (To answer research question 5b)

H_{08}: There is no significant relationship between low-performing secondary students' behavioural intention to apply STEM practices in learning science with perceived behavioural control through the implementation of a STEM programme. (To answer research question 6a)

H_{09}: There is no significant relationship between low-performing secondary students' behavioural intention to apply STEM practices in learning science with subjective norm through the implementation of a STEM programme. (To answer research question 6b)

H_{10}: There is no significant relationship between low-performing secondary students' behavioural intention to apply STEM practices in learning science with perceived usefulness through the implementation of a STEM programme. (To answer research question 6c)

H_{11}: There is no significant relationship between low-performing secondary students' behavioural intention to apply STEM practices in learning science with perceived ease of use through the implementation of a STEM programme. (To answer research question 6d)

H_{12}: There is no significant relationship between low-performing secondary students' behavioural intention to apply STEM practices in learning science with attitude through the implementation of a STEM programme. (To answer research question 6e)

1.7 Conceptual Framework

The selected relevant theories and model of conceptual framework including Theory of Constructivism, Combined TAM and TPB (C-TAM-TPB) and Holland's Theory of Vocational Choice. The theory of constructivism focuses on the role of active learners to discover new information by building it on the prior learning experience. The theory of constructivism was used to design STEM programme which encourage students actively explore in STEM learning. Besides, Design-Based Research (DBR) approach was applied as an overall guideline in creating design principles for the STEM programme in three iterative cycles with systematic steps. The implementation STEM programme in this study aimed to investigate low-performing students' intention in exploring skilled careers through ILP virtual tour as well as mastering the STEM practices that would be applied to their daily life, future learning and career. The designed STEM activities required students to plan their own hands-on investigation by employing higher-order thinking skills. In a meanwhile, comparison group students underwent school-based career talk with science activities based on the selected topics.

The combination of TAM and TPB in this study is adapted from the augmented TAM or C-TAM-TPB proposed by Taylor and Todd (1995). The hybrid C-TAM-TPB model included the variables in TAM and the social as well as control variables which are fundamental determinants in the TPB. This study applied the C-TAM-TPB model to provide a more comprehensive investigation of the important determinants of usage towards STEM practices. The C-TAM-TPB model was adapted and implemented in this study to observe students' behavioural intention in using STEM practices through the interaction with local communities and daily life application during the STEM programme.

The first part of C-TAM-TPB was similar to the TAM model whereas the second part applied the variables from TPB. The adapted TAM model was used to explore the prospect of the developed STEM programme that applied on low academic performance students in term of perceived ease of use, perceived usefulness, attitude and behavioural intention (Teo, Wong, & Chai, 2008). As TAM survey only provided general evidence on students' responses about STEM practices, the supplementary constructs from TPB were added for better understanding of students' behavioural intention to apply STEM practices in learning science. The supplementary construct selected from TPB included subjective norm and perceived behavioural control as the other constructs such as perceived ease of use, perceived usefulness, attitude and behavioural intention were evaluated by TAM survey. The construct of subjective norm mentioned in TPB was determined by the influence of important person and perceived social pressure on students' behavioural intention whereas perceived behavioural control examined students' self-efficacy and autonomy to perform STEM practices. All the six constructs from C-TAM-TPB were included in the pre-survey and post-survey questionnaire to evaluate students' intention towards the STEM practices.

Students need to equip with occupational knowledge to make more adequate vocational choices (Holland, 1959). Holland's theory with descriptive and simple guideline was useful for students to explore their own interests using Holland RIASEC codes and opt for perceived vocational options depends on their preferable working environment. The personality type that matched with the compatible working environment led students to their desired future course of study or career in success. The Holland Self-Directed Search (SDS) test was adapted in the survey questionnaire to investigate students' perceived vocational options by evaluating their interested activities, competencies and occupations in the six different personality types (Holland, Fritzsche, & Powell, 1994).

The outcome was further analysed for the investigation of the relationship between low-performing secondary students' behavioural intention to perform STEM practices through STEM programme with the selected constructs. The correlation between perceived ease of use, perceived usefulness and attitude were examined in this study. Both theories and model chosen as shown in Figure 1.1 were important to serve as an adapted framework of reference to identify and conceptualise the research problems. The main constructs in TPB which used to measure students' behavioural intention were linked with other relevant theories and models. The connection between the theories and models were summarised in the next chapter as Table 2.1.

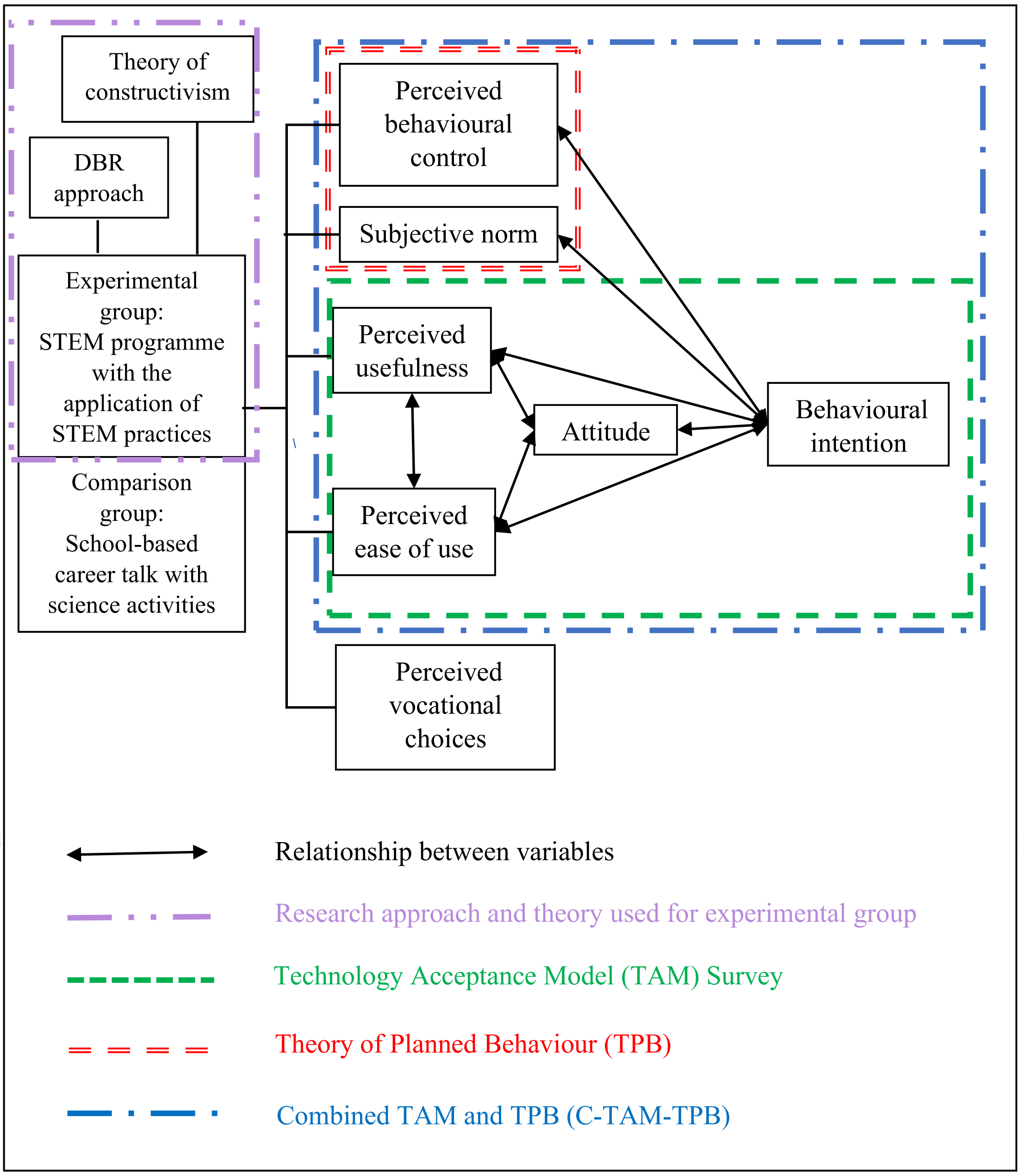

Figure 1.1. Research Conceptual Framework

1.8 Significance of the Study

This study emphasised on helping low-performing students for better future study and career plan. This allowed students to have an idea and awareness about vocational choices based on their personal interests and competencies. The interactive programme collaborated with ILP also offered students an opportunity to increase students' awareness of vocational study path and explore skills-based careers in depth. This provided another option for students to acquire valuable workplace skills after graduated from secondary school.

Moreover, this research aimed to assist low-performing student in enhancing their motivation in science learning through the use of STEM practices. Engaging in STEM group activity is able to stimulate logical development and problem-solving skills among students. In this study, developed STEM programme with the use of mobile application software (apps) and Virtual Reality (VR) content is attracted students' attention as students can involve themselves in an interesting way of learning. This research study also can probably inspire students to apply the STEM practices learned from the guided STEM activities into their daily life activities and learning process as well as future career. This will promote the learning process happened at anytime and anywhere.

This study is able to raise teachers' awareness for the implementation of innovative learning activities or programme including self-developed STEM activities by using educational technology such as VR in secondary school. Educators should take advantages of educational technology to deliver knowledge through an interactive and collaborative learning process. As most of the teachers in Malaysia still prefer traditional teacher-centered learning, this research encourages teachers to shift their teaching style to more progressive modern teaching. This study is helpful for teachers to review and reflect on their current teaching strategies with respect to the learning objectives. The developed STEM programme with study pathways and career talk also can be used as a guideline for school counsellor in organising similar programmes. This will encourage school counsellor in promoting more skills-based courses in order to help low-achievers in their future study and career path.

Furthermore, this research can be used as a reference for the Ministry of Education to advocate STEM learning at other education levels such as the primary level. This study indirectly contributed to the achievement of government policy such as developing students' ICT literacy, minimising wastes of valuable resources and maximising use of community supplies. Besides, this research can deliver meaningful data for teachers, counsellor and educators regarding their teaching methods, resources, and goals that can facilitate and improve teaching strategies.

1.9 Limitations and Delimitations of the Study

There are six limitations and three delimitations identified in this study. One of the limitations of this study was the sample size. The number of students in an intact class was set by the school authorities based on the criteria of students' performance such as low performers selected in this study. The sample of this research only involved 68 students for both experimental group and comparison group from two national mainstream schools. The small sample of respondents might not represent the majority of students in Malaysia. In order to generalise the results to a larger population, a larger sample size and funding are required in the future study.

In geographical scope, the accessible population of the study was limited to the secondary students in the state of Perak, Malaysia due to several constraints. Physical limitation and budgetary constraints restricted the data collection from sizable study group across a large region. Moreover, students were not allowed to carry their personal gadgets such as laptop and smartphone to school to prevent

discipline issues. Therefore, school computers and several limited smartphones were provided for students to perform the STEM activities. Students only allowed using the electronic gadget after school time or out of the school compounds. The results of the study only implied the STEM programme that carried out in six weeks due to limited time constraint. The results will be more precise if a longitudinal study or longitudinal survey is conducted in a longer period to study long term effects on student's behavioural intention.

Additionally, this research also faced Malaysia Movement Control Order (MCO) or lockdown restricting due to COVID-19 pandemic. Online communication was inefficient for receiving immediate feedback from school authorities and students.

Hybrid learning that implemented in the whole nation led to poor attendance in school which prolong the data collection process.

Furthermore, the research sample was delimited to low-performing Form 4 students who obtained grade C and below. The scope of STEM activity in this study focused on the topic of secondary school science syllabus such as sound waves, force and motion as well as nuclear energy. This study covered certain related variables for investigation such as perceived ease of use, perceived usefulness, attitude, subjective norm, perceived behavioural control, perceived vocational choices and behavioural intention. The other extraneous variables as mentioned in the section 3.3 that might affect the findings were excluded from this study.

1.10 Operational Definitions

The operational definitions used in the study were defined as follow:

1.10.1 Low-performing Students

Low-performing students are "students who score below Level 2 on the Programme for International Student Assessment (PISA) mathematics, reading and/or science scales" (OECD, 2016, p. 37). Low-performing students in this study were categorised as Form 4 secondary school students who obtained grades that range from credit to failed (grade C to G) in their previous final science or mathematics examination.

Table 1.1

Sijil Pelajaran Malaysia (SPM) Grading System (Daneil, 2019)

Grades	Grade Value	Interpretation
A+	0	Super Distinction
A	1	High Distinction
A-	2	Distinction
B+	3	Super Credit
B	4	High Credit
C+	5	Upper Credit
C	6	Credit
D	7	Upper Pass
E	8	Pass
G	9	Fail

1.10.2 STEM Programme

STEM education is "a teaching and learning method which applies integrated knowledge, skills and values of STEM through inquiry, problem solving or project in the context of daily life, environment and local as well as global community" (MOE, 2018b, p.24). The implementation of the STEM programme in this study applied the concept of STEM education and cultivated eight STEM practices to encourage the engagement of students in hands-on science learning activities and interaction with a local institution such as ILP. The eight STEM practices listed in the syllabus included "(a) questioning and identifying problems; (b) developing and using models; (c) planning and carrying out investigations; (d) analysing and interpreting data; (e) using mathematical and computational thinking; (f) developing explanations and designing solutions; (g) engaging in argument and discussion based on evidence; and (h) acquiring information, evaluating and communicating about the information." (MOE, 2018b, p. 24). In this study, the STEM programme is a package of lessons including a virtual tour of ILP and guided group activities with the use of educational technology such as smartphone apps and VR. This STEM programme was developed based on DBR approach and theory of constructivism.

1.10.3 Evaluation

According to Mathison (2004), the evaluation is an applied investigative phase for the collection and synthesis of information, resulting in findings on the value and quality of the programme. In this study, the STEM programme was evaluated by investigating low-performing secondary students' behavioural intention to use STEM practices in learning science with selected factors including subjective norm, perceived behavioural control, attitude, perceived usefulness, and perceived ease of use. These constructs were measured by using questionnaire, open-ended questions, interview and observation checklist.

An impact study aims to assess whether an educational intervention has initiated any relevant outcome variables (Longva & Foss, 2018). There has been significant growth in the impact of educational studies on various aspects such as STEM career development (Blustein et al., 2013; Çevik, 2018), academic performance (Çevik, 2018; Emdin, Adjapong, & Levy, 2016; Thomas, Bonner, Everson, & Somers, 2015; Wallace, Perry, Ferguson, & Jackson, 2014), STEM interest (Mohd Shahali, Halim, Rasul, Osman, & Mohamad Arsad, 2019) and STEM skills (Ardianti, Sulisworo, Pramudya, & Raharjo, 2020). However, the present study concerned whether the STEM programme implementation induced a change of behavioural intention of low-performing students towards STEM practices in learning science.

1.10.4 Correlation

A correlation in research is defined as a positive or negative association between two or more variables to decide whether they influence each other by using a correlation statistical test (Creswell, 2008). The current study was designed to establish the association between perceived behavioural control, subjective norm, perceived usefulness, perceived ease of use and attitude with students' behavioural intention towards STEM practices. The correlation between perceived ease of use, perceived usefulness and attitude were also included according to the C-TAM-TPB model.

1.10.5 Behavioural Intention

Behavioural intention refers to the possibility or degree of strength of one's intention to accomplish a particular behaviour (Fishbein & Ajzen, 1975). According to TAM, behavioural intention is developed as an outcome of conscious decision-making process that will lead to usage behaviour (Venkatesh, Morris, Davis, & Davis, 2003). This study investigated how likely students will have their intention to perform STEM practices in future science learning. Thus, students' behavioural intention were evaluated as the dependent variable by using adapted TAM survey questions (Davis, 1989; Park, Nam, & Cha, 2012; Teo et al., 2008) and TPB survey questionnaire (Ajzen, 2006; Francis et al., 2004).

1.10.6 Subjective Norm

Ajzen (1991) defined subjective norm as the perceived societal obligation to conduct the action. The present study indicated subjective norm as perceived societal influences of students from important peoples around them to perform STEM practices.

1.10.7 Perceived Behavioural Control

Perceived behavioural control can be outlined as the perceived simplicity or complexity of carrying out the behaviour (Ajzen, 1991). This study defined perceived behavioural control as perceived ease or difficulty for students to confidently cultivate STEM practices in science learning or daily life activities.

1.10.8 Attitude

Attitude is the degree to which an individual has a positive or negative judgment or evaluation of the behaviour concerned (Ajzen, 1991). The present study examined students' positive or negative judgment on science learning with the use of STEM practices.

1.10.9 Perceived Usefulness

The perceived usefulness can be defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989, p.320). In this study, perceived usefulness referred to the extent of students' belief on the application of STEM practices will enhance science learning.

1.10.10 Perceived Ease of Use

The perceived ease of use denoted as "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, p.320). In this study, perceived ease of use can be described as students' belief on the STEM practices are easy to use in future learning.

Hence, all the variables listed in the C-TAM-TPB model such as perceived behavioural control, subjective norm, perceived usefulness, perceived ease of use, attitude and behavioural intention were included in this study (Taylor & Todd, 1995a). In other words, behavioural intention was one of the constructs examined in this study (Ho, Hung, & Chen, 2013; Yang & Su, 2017).

1.10.11 Perceived Vocational Choices

Despite the constructs listed in the C-TAM-TPB model, this study also investigated students' perceived vocational choices. Vocational choice is the decision of a career where a person's individual traits interact with a diversity of cultural, subjective influences and physical circumstances (Holland, 1959). Perceived vocational choices are determined in this study by using Holland SDS based on students' personality types, interested activities, competencies and occupations in Realistic (R), Investigative (I), Artistic (A), Social (S), Enterprising (E), and Conventional (C) working environment (Holland, et al., 1994). This study focused on Realistic and Investigative domain which are closely related to the virtual tour of industrial training college that matched with vocational careers while the STEM activity that corresponded to STEM careers. As a result, the student can obtain their perceived vocational choices and interest for further study and related careers in STEM or TVET field.

1.11 Summary

This chapter provided a brief introduction, continued by the background of the study which included some remarks by previous studies on STEM education. The central problem of this study was stated followed by six research objectives and six research questions. Then, the significance of this study was affirmed. Next, the limitation and delimitations of this study were justified before ending with the operational definition of terms used in this research.