DEVELOPMENT AND EFFECTIVENESS OF FACTORISATION AND ALGEBRAIC FRACTIONS MOBILE-LEARNING (FAM) MODULE ON FORM TWO STUDENTS' ACHIEVEMENT AND INTEREST IN ALGEBRA

05-4506832 pustaka.upsi.edu.my Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah PustakaTBainun ptbupsi

PUNETHN A/L SUPERMINIUM

SULTAN IDRIS EDUCATION UNIVERSITY

2023

05-4506832 pustaka.upsi.edu.my Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah PustakaTBainun ptbupsi

DEVELOPMENT AND EFFECTIVENESS OF FACTORISATION AND ALGEBRAIC FRACTIONS MOBILE-LEARNING (FAM) MODULE ON FORM TWO STUDENTS' ACHIEVEMENT AND INTEREST IN ALGEBRA

PUNETHN A/L SUPERMINIUM

DISSERTATION PRESENTED TO QUALIFY FOR A MASTER'S DEGREE IN MATHEMATICS EDUCATION (RESEARCH MODE)

FACULTY OF SCIENCE AND MATHEMATICS
SULTAN IDRIS EDUCATION UNIVERSITY

2023

UPSI/IPS-3/BO 32
Pind : 00 m/s: 1/1

UNIVERSITI PENDIDIKAN SULTAN IDRIS
SULTAN IDRIS EDUCATION UNIVERSITY

Sila tanda (√)
Kertas Projek
Sarjana Penyelidikan ✓
Sarjana Penyelidikan dan Kerja Kursus
Doktor Falsafah

INSTITUT PENGAJIAN SISWAZAH

PERAKUAN KEASLIAN PENULISAN

Perakuan ini telah dibuat pada 16 (hari bulan) OKTOBER (bulan) 20 23

i. Perakuan pelajar :

Saya, PUNETHN A/L SUPERMINIUM (M20201000297) FAKULTI SAINS DAN MATEMATIK (SILA NYATAKAN NAMA PELAJAR, NO. MATRIK DAN FAKULTI) dengan ini mengaku bahawa disertasi/tesis yang bertajuk DEVELOPMENT AND EFFECTIVENESS OF FACTORISATION AND ALGEBRAIC FRACTIONS MOBILE-LEARNING (FAM) MODULE ON FORM TWO STUDENTS' ACHIEVEMENT AND INTEREST IN ALGEBRA adalah hasil kerja saya sendiri. Saya tidak memplagiat dan apa-apa penggunaan mana-mana hasil kerja yang mengandungi hak cipta telah dilakukan secara urusan yang wajar dan bagi maksud yang dibenarkan dan apa-apa petikan, ekstrak, rujukan atau pengeluaran semula daripada atau kepada mana-mana hasil kerja yang mengandungi hak cipta telah dinyatakan dengan sejelasnya dan secukupnya

Tandatangan pelajar

ii. Perakuan Penyelia:

Saya, PROF. MADYA DR. MOHD FAIZAL NIZAM LEE BIN ABDULLAH (NAMA PENYELIA) dengan ini mengesahkan bahawa hasil kerja pelajar yang bertajuk DEVELOPMENT AND EFFECTIVENESS OF FACTORISATION AND ALGEBRAIC FRACTIONS MOBILE-LEARNING (FAM) MODULE ON FORM TWO STUDENTS' ACHIEVEMENT AND INTEREST IN ALGEBRA (TAJUK) dihasilkan oleh pelajar seperti nama di atas, dan telah diserahkan kepada Institut Pengajian Siswazah bagi memenuhi sebahagian/~~sepenuhnya~~ syarat untuk memperoleh Ijazah SARJANA PENDIDIKAN MATEMATIK (SLA NYATAKAN NAMA IJAZAH).

16.10.2023

Tarikh

Tandatangan Penyelia

Prof. Madya Dr. Mohd Faizal Nizam Lee Abdullah S.I.S
Dekan
Fakulti Sains Dan Matematik
Universiti Pendidikan Sultan Idris

UPSI/IPS-3/BO 31
Pind.: 01 m/s:1/1

UNIVERSITI PENDIDIKAN SULTAN IDRIS
SULTAN IDRIS EDUCATION UNIVERSITY

INSTITUT PENGAJIAN SISWAZAH /
INSTITUTE OF GRADUATE STUDIES

BORANG PENGESAHAN PENYERAHAN TESIS/DISERTASI/LAPORAN KERTAS PROJEK
DECLARATION OF THESIS/DISSERTATION/PROJECT PAPER FORM

Tajuk / *Title*: DEVELOPMENT AND EFFECTIVENESS OF FACTORISATION AND ALGEBRAIC FRACTIONS MOBILE-LEARNING (FAM) MODULE ON FORM TWO STUDENTS' ACHIEVEMENT AN INTEREST IN ALGEBRA

No. Matrik /*Matric's No.*: M20201000297

Saya / *I* : PUNETHN A/L SUPERMINIUM

(Nama pelajar / *Student's Name*)

mengaku membenarkan ~~Tesis~~/Disertasi/~~Laporan Kertas Projek (Kedoktoran~~/Sarjana)* ini disimpan di Universiti Pendidikan Sultan Idris (Perpustakaan Tuanku Bainun) dengan syarat-syarat kegunaan seperti berikut:-
acknowledged that Universiti Pendidikan Sultan Idris (Tuanku Bainun Library) reserves the right as follows:-

1. Tesis/Disertasi/Laporan Kertas Projek ini adalah hak milik UPSI.
   The thesis is the property of Universiti Pendidikan Sultan Idris

2. Perpustakaan Tuanku Bainun dibenarkan membuat salinan untuk tujuan rujukan dan penyelidikan.
   Tuanku Bainun Library has the right to make copies for the purpose of reference and research.

3. Perpustakaan dibenarkan membuat salinan Tesis/Disertasi ini sebagai bahan pertukaran antara Institusi Pengajian Tinggi.
   The Library has the right to make copies of the thesis for academic exchange.

4. Sila tandakan (√) bagi pilihan kategori di bawah / *Please tick (√) for category below:-*

☐	**SULIT/*CONFIDENTIAL***	Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub dalam Akta Rahsia Rasmi 1972. / *Contains confidential information under the Official Secret Act 1972*
☐	**TERHAD/*RESTRICTED***	Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan ini dijalankan. / *Contains restircted information as specified by the organization where research was done.*
√	**TIDAK TERHAD / *OPEN ACCESS***	

(Tandatangan Pelajar/ Signature)

Tarikh: 16.10.2023

(Tandatangan Penyelia / *Signature of Supervisor*)
& (Nama & Cop Rasmi / *Name & Official Stamp*)

Prof. Madya Dr. Mohd Faizal Nizam Lee Ab...
Dekan
Fakulti Sains Dan Matematik
Universiti Pendidikan Sultan Idris

Catatan: Jika Tesis/Disertasi ini **SULIT @ TERHAD**, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan ini perlu dikelaskan sebagai **SULIT** dan **TERHAD**.

Notes: If the thesis is CONFIDENTAL or RESTRICTED, please attach with the letter from the organization with period and reasons for confidentiality or restriction.

ACKNOWLEDGEMENT

All the praises and thanks be to God for the blessings of wisdom, health and courage to enable me to complete this master's journey. Thank you for giving me the strength to overcome adversity and rise above negativity. After all the hurdles and challenges, taking small steps at a time, You made it possible. To my beloved wife, V.S Giita, thank you for being very understanding throughout my study. You are my source of love, inspiration, enthusiasm and strength for continuing this master's journey. I am more grateful to you than you will ever know. To my heroes, Dhruv and Darvind, thank you for cheering me with your waves of laughter. To my wonderful mother, Devi Palaniappan, and brother, Panneer, who had never stopped believing in me, thank you for your continuous support. My heartfelt thanks to my supervisors, Associate Professor Dr Mohd Faizal Nizam Lee bin Abdullah and Dr Murugan Rajoo, for their time and effort in providing constructive feedback and criticism. A special thanks to Dr Murugan for being receptive to new ideas and points of view. Both of you have been excellent mentors that a student could ask for. A special thank you to my buddies, Wafrah and Ramesh, for their endless support and words of encouragement. They calmed me every time I had anxiety attack and patiently waited for me to end my study leave. Words cannot express how much it means to me. I would also like to thank my friends Punithavilli Mariappan and Nurul Ain Malek for showing me that this is not a solo journey. Thank you to the panel of experts who were the key contributor to the development of the FAM module. I thank the students and teachers who participated in this study. I am also thankful to the Education Department of the Federal Territory of Kuala Lumpur for allowing me to conduct the study in the selected school. Lastly, thank you to the Malaysia Ministry of Education for awarding the full scholarship and providing me with the opportunity to learn and grow.

ABSTRACT

This study aimed to develop the Factorisation and Algebraic Fractions Mobile-learning (FAM) module and test its effectiveness on Form Two students' achievement and interest in algebra. This study uses the design and development research (DDR) approach comprised of three phases, namely, (i) need analysis, (ii) design and development, and (iii) evaluation. The FAM module was developed using the ADDIE and Mobile Edu model. Meanwhile, to evaluate the effectiveness of the FAM module, a quasi-experimental design was used, specifically the pretest-posttest non-equivalent control group design involving 69 Form Two students from a secondary school in Kuala Lumpur chosen using a clustered random sampling technique. Data collected were analysed using descriptive statistics, namely mean and standard deviation. Meanwhile, inferential statistics, namely t-test, MANOVA, and Pearson correlation, were used for hypothesis testing. This finding shows that the FAM module has good validity based on experts' consensus. Next, the results of the t-test revealed a significant difference whereby the mean achievement score of the treatment group was higher than the control group. The MANOVA test using Pillai's Trace revealed a significant difference in the three constructs of interest (positive valence, negative valence, and time) between the control and treatment groups. Subsequently, the Pearson correlation test revealed a significant, strong positive relationship between students' achievement in Factorisation and Algebraic Fractions and interest in learning algebra. In conclusion, the FAM module developed could improve students' achievement in Factorisation and Algebraic Fractions and positively affect students' interest in learning algebra. The implication of the study suggests that the developed FAM module shows that mobile learning can improve students' achievement in Factorisation and Algebraic Fractions and interest in algebra.

PEMBANGUNAN DAN KEBERKESANAN MODUL PEMBELAJARAN MUDAH-ALIH PEMFAKTORAN DAN PECAHAN ALGEBRA (FAM) TERHADAP PENCAPAIAN DAN MINAT DALAM ALGEBRA BAGI MURID TINGKATAN DUA

ABSTRAK

Kajian ini bertujuan membangun dan menguji keberkesanan Modul Pembelajaran Mudah-alih bagi topik Pemfaktoran dan Pecahan Algebra (FAM) terhadap pencapaian dan minat murid Tingkatan Dua dalam algebra. Kajian ini menggunakan pendekatan reka bentuk dan pembangunan (PRP) yang terdiri daripada tiga fasa iaitu (i) analisis keperluan, (ii) reka bentuk dan pembangunan, dan (iii) penilaian. Modul FAM dibangunkan berasaskan model ADDIE dan Mobile Edu. Manakala, keberkesanan modul FAM dinilai menggunakan kajian kuasi eksperimen ujian pra-pos kumpulan kawalan tidak setara ke atas 69 orang murid Tingkatan Dua di sebuah sekolah menengah kebangsaan di Kuala Lumpur yang dipilih secara persampelan rawak berkelompok. Data yang dikumpulkan dianalisis secara deskriptif menggunakan min dan sisihan piawai. Manakala statistik inferensi menggunakan ujian-t, MANOVA dan korelasi Pearson digunakan untuk ujian hipotesis. Dapatan kajian menunjukkan bahawa modul FAM mempunyai nilai kesahan yang baik berdasarkan persetujuan pakar. Seterusnya., dapatan kajian ujian-t menunjukkan perbezaan yang signifikan, dengan keadaan min skor pencapaian kumpulan rawatan lebih tinggi berbanding min skor pencapaian kumpulan kawalan. Ujian MANOVA menggunakan *Pillai's Trace* menunjukkan wujud perbezaan yang signifikan antara ketiga-tiga konstruk minat (kecenderungan positif, negatif dan masa) antara kumpulan kawalan dan rawatan setelah masing-masing menggunakan kaedah konvensional dan modul FAM. Manakala, dapatan korelasi Pearson menunjukkan wujud korelasi positif dan signifikan antara pencapaian murid dalam topik Pemfaktoran dan Pecahan Algebra dan minat dalam algebra. Kesimpulannya, modul FAM yang dibangunkan dapat meningkatkan pencapaian murid dalam Pemfaktoran dan Pecahan Algebra. Disamping itu, modul ini juga menunjukkan kesan positif terhadap minat dalam algebra. Implikasinya, modul FAM yang dibangunkan menunjukkan bahawa pembelajaran mudah alih dapat meningkatkan pencapaian bagi topik Pemfaktoran dan Pecahan Algebra dan minat murid dalam algebra.

TABLE OF CONTENTS

Pages

05-4506832 pustaka.upsi.edu.my Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah PustakaTBainun ptbupsi

05-4506832 pustaka.upsi.edu.my Perpustakaan Tuanku Bainun Kampus Sultan Abdul Jalil Shah PustakaTBainun ptbupsi

LIST OF TABLES

Table No. **Page**

LIST OF FIGURES

Figure No. **Page**

LIST OF ABBREVIATIONS

ADDIE	Analyse, Design, Develop, Implement, Evaluate
ANOVA	Analysis of Variance
BPK	*Bahagian Pembangunan Kurikulum*
COVID-19	Coronavirus Disease 2019
CVI	Content Validity Index
DELIMa	Digital Educational Learning Initiative Malaysia
DDR	Design and Development Research
DSKP	*Dokumen Standard Kurikulum dan Pentaksiran*
EPRD	Educational Planning and Research Division
FAFT	Factorisation and Algebraic Fraction Test
FAM	Factorisation and Algebraic Fractions Mobile-learning
HOTs	Higher Order Thinking Skills
ICT	Information Communication and Technology
KSSM	*Kurikulum Standard Sekolah Menengah*
MANOVA	Multivariate Analysis of Variance
MCQ	Multiple-choice Questions
MEB	Malaysian Education Blueprint
MEQ	Module Evaluation Questionnaire
MII	Mathematics Interest Inventory
MOE	Malaysian Ministry of Education
MVQ	Module Validity Questionnaire

NAQ	Need Analysis Questionnaire
PADU	Education Performance and Delivery Unit
PISA	Programme for International Student Assessment
PKLSM	*Pentaksiran Kompetensi dan Literasi Sekolah Menengah*
SPSS	Statistical Package for Social Sciences
STEM	Science, Technology, Engineering and Mathematics
TBL	Thinking Based Learning
TIMSS	Trends in International Mathematics and Science Studies
TPACK	Technological, Pedagogical and Content Knowledge
TST	Test Specification Table
ZPD	Zone of Proximal Development

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

The education landscape is evolving faster than before, parallel with the emergence of technologies (Fatawi et al., 2020). Technology integration in education refers to using technology resources to support teaching and learning (Novita & Herman, 2021). Effective use of technology has yielded various benefits and impacts in education. Studies show that technology integration enables learners to engage actively in learning (Fatawi et al., 2020). Technology integration in learning also allows educators to implement differentiated instructions accommodating students' unique needs and learning abilities (Hanimoglu, 2018; Kumi-Yeboah et al., 2020). Moreover, technology integration also increases learning engagement among students with different learning styles (Lacey & Wall, 2021; Viorica-Torii & Carmen, 2013). The use of technology also enables learning resources to be accessed and shared easily using various platforms (Raja & Nagasubramani, 2018).

The diversity of educational technology tools allows integration to be implemented for multiple levels of students. For elementary-level students, technology is used to build an excellent essential skill required for their future independent learning (Jong, 2020). Educational technology tools such as interactive games can reinforce literacy and numeracy skills among elementary-level students (Miller, 2018; Rogowsky et al., 2018). Meanwhile, technology is utilised by middle-school and high-school learners to foster creative and critical thinking skills (Wan Nur Tasnim et al., 2019), problem-solving, communication, and higher-order thinking skills essential for 21st-century education (Diyana et al., 2017). Thus, educational institutions are incorporating technologies into learning to create a holistic learning experience for students from all levels.

Technology integration is not solely bound to physical classroom instructions but is also utilised in virtual classrooms. Integrating technology in education has become prominent along with the rapid development of the internet and digital technologies such as electronic devices, online tools, mobile applications, learning management systems, and online resources (Bray & Tangney, 2017). Likewise, the Malaysian Ministry of Education (MOE) has launched the Digital Educational Learning Initiative Malaysia (DELIMa) platform, which offers a series of applications, services, and learning resources required by teachers and students. These include Microsoft Office 365, Apple Teacher Learning Center, Google Classroom, Padlet, Blendspace, Quizizz, Kahoot, and Edpuzzle (Menon, 2020). This initiative is in line with the seventh shift in the Malaysia Education Blueprint (2013 – 2025). In this shift, the ministry aims to utilise information, communication, and technology (ICT) to provide distance and self-paced learning and create broader accessibility for high-quality teaching irrespective of students' location or skill levels (MOE, 2013).

As a result, digital learning using mobile devices, also known as the mobile-learning, has been gaining tremendous interest among mathematics educators to be implemented in their instructional strategies (Liu et al., 2021; Qureshi et al., 2020). Mobile learning is regarded as a dynamic instructional strategy to support 21st-century education, as it provides access to learning without boundaries (Dias & Victor 2017). Mobile devices such as smartphones, tablets, and notebooks have been omnipresent components in the daily life of students and teachers; thus, mobile learning has given the leverage for teachers and students to be engaged with learning activities ubiquitously (Nikolopoulou, 2018). Mobile learning also encourages autonomous learning as students can engage in learning activities at their own pace (Dissanayake & Velananda, 2020; Schuck et al., 2017). On top of that, the ongoing development of digital tools for mathematics education creates a brighter pathway for implementing mobile learning as an effective instructional strategy for teaching and learning mathematics.

The following section in this chapter describes the background of the study and the problem statement, which describes the issues and reasons for this study to be carried out. This is followed by the research purpose, research objectives, research questions and research hypotheses of the study. Subsequently, this chapter also includes a brief description of the conceptual framework, significance, operational definitions and the limitations of the study.

1.2 Background of Study

Education plays a prominent role in a nation's economic growth and development (MOE, 2013). To improve the quality of education in Malaysia, the MOE receives an enormous allocation from the yearly budget (Malaysian Ministry of Finance, 2020). Following the rapid change in the global education system, Malaysia had inked a significant transformation in the education policy parallel to the modernisation trend by developing the Malaysia Education Blueprint (MEB) 2013 – 2025 (MOE, 2013). The Malaysia Education Blueprint provides a clear vision for the future of the education system in Malaysia and the students' aspiration to achieve the needs of the 21st century. Following that, the ministry has outlined 11 strategic and operational shifts, which will be implemented across three stages, namely the first wave (2013 – 2015), the second wave (2016 – 2020), and the third wave (2021 – 2025). Among the eleven transformation shifts, the first shift in the Malaysia Education Blueprint 2013-2025 emphasises equal access to quality education of an international standard (MOE, 2013).

Under this shift, the ministry aims to benchmark mathematics learning to international standards and strengthen the quality of Science, Technology, Engineering and Mathematics (STEM) education in Malaysia (MOE, 2013). In line with that, the Ministry of Education Malaysia (MOE) launched the Secondary School Standard Curriculum (KSSM) in 2017. The new curriculum has been revised to embrace essential knowledge and skills, including creative thinking, innovation, problem-solving, and leadership (MOE, 2013). Being one of the core subjects in KSSM, mathematics has gone through a revamp in the syllabus along with the teaching and learning approaches. The new curriculum aims to develop mathematical thinking among students based on learning areas, values, skills and mathematical processes (MOE, 2015). The KSSM Mathematics also aims to foster higher-order thinking skills (HOTs) and 21st-century skills among students to compete globally.

In this curriculum, higher-order thinking skills emphasise four levels of thinking: application, analysis, evaluation and creation (MOE, 2017). These skills enable students to use knowledge, skills and values with rational and logical consideration for reasoning and decision-making using innovative ways (MOE, 2017). Meanwhile, 21st-century skills refer to the knowledge and competencies that need to be acquired to enter the workforce of the current economy and social development (Van Laar et al., 2017). In the Malaysian context, 21st-century skills are defined as *"a set of skills and competencies that are aligned with the National Education Philosophy and will give Malaysian students an internationally competitive edge"* (MOE, 2013).

Higher-order thinking skills are essential to produce creative, critical and competitive students at an international level (MOE, 2013). These skills align with 21st-century skills, which help students independently address the social, scientific and practical problems found in future (Miterianifa et al., 2021). Thus, through curriculum, the ministry aims to create balanced students, able to withstand challenges, are curious about learning, possess honesty and morality, are knowledgeable, concerned for others, are patriotic towards the nation and are effective in thinking, communication and collaborating with others (MOE, 2013).

Meanwhile, algebra, one of the core domains in secondary school mathematics, has frequently gained attention among researchers worldwide. Mastering the knowledge and skills related to algebra is essential because it serves as a pre-requisite and is interconnected to multiple disciplinary in mathematics required in our daily life (Nurhayati et al., 2017). Students' mastery of algebra is also found to impact their performance in higher-level mathematics (Marpa, 2019). In addition to that, algebra is also vital in international assessments such as Trends in International Mathematics and Science Study (TIMSS) and Programme for International Student Assessment (PISA). In Trends in International Mathematics and Science Studies (TIMSS), algebra covers 30% of the overall assessment, which is divided into expressions, operations, and equations (20%) and relationships and functions (10%) (EPRD, 2020). Meanwhile in PISA, the ability of students to describe, model, and analyse the concept of change and relationships involving real-life situations using algebraic expressions, equations, inequalities, and suitable functions is assessed (OECD, 2018).

Despite the perceived usefulness of this domain in mathematics, students still have difficulties learning and comprehending it (Teh et al., 2020; Mazlini & Nurul Sarah, 2016). Algebra is well-known as a complex topic in the secondary school mathematics curriculum and frequently felt as a stumbling block (Al-Rababaha et al., 2020). Among the common difficulties faced by students in algebra are difficulties in differentiating between arithmetic and algebraic terms (Indraswari et al., 2018), misconceptions in solving rational algebraic expressions (Umanah, 2020), and misconceptions in solving factorisation and expansion of algebraic expressions (Al-Rababaha et al., 2020).

Many studies have been done locally and internationally to minimize the difficulties in teaching and learning algebra. Sun-Lin and Chiou (2019) investigate the effectiveness of using gamification in teaching algebraic word problem-solving. Najihah et al. (2018) investigate the effectiveness of integrated algebraic thinking into problem-based learning. Additionally, Azura and Siti Mistima (2020) studied the effect of video-animated-based learning on students' understanding of algebra. Nur Alwani and Mohd Faizal Nizam Lee (2021) developed a teaching aid known as Algebra Board for the topic of Linear Equations in One Variable. Meanwhile, Saundarajan et al. (2020) investigate the effectiveness of augmented reality in learning algebra using the Photomath application. Although many studies have been carried out constantly to support the teaching and learning of algebra, there are still windows to introduce approaches that could make the concept successfully mastered by students with multiple learning needs and abilities.

Therefore, the Ministry of Education has urged the teachers to shift the current teaching and learning paradigm from teacher-centred learning to student-centred learning (MOE, 2015). Through this approach, teachers play the role of facilitators, who help students construct meaningful new knowledge based on the student's experience while engaging actively and independently in the learning processes (Anizam et al., 2017; Saundarajan, 2020). In line with that, teachers are urged to plan their teaching and learning activities by incorporating multiple strategies. These strategies must be aligned with student-centred learning, such as inquiry-based learning, problem-based learning, project-based learning, digital learning, and others. These measures give students an in-depth understanding and higher-level thinking (MOE, 2015; Mohd Paris & Saedah, 2016; Ting & Rohani, 2016). According to Bahagian Pembangunan Kurikulum (BPK) (2016), the teaching and learning strategies need to embed with fun learning and yet meaningful approaches to meet the needs of students from different perspectives and learning abilities.

According to Keefe in Costa et al. (2020), learning style refers to the cognitive, affective and physiological characteristics used as a stable criterion for how learners comprehend and interact in their learning environment. One of the common learning styles among students is visual, aural, reading/writing and kinesthetic, also known as VARK, by Flemings and Mills (1992). An effective instructional strategy based on students' learning styles increases their interest and engagement in learning, subsequently influencing their academic achievement (Mozaffari et al., 2020). Thus, it is vital for teachers to consider students' learning styles, assessment methods, suitability of teaching and learning materials and flexibility of the learning environment (BPK, 2016). Therefore, research involving instructional design must be carried out continuously to revamp the teaching and learning of mathematics, specifically the topics of algebra.

1.3 Problem Statement

Several critical issues have been highlighted based on works of literature. First and foremost is the decline in students' achievement in national and international mathematics assessments. In 2019, the *Pentaksiran Kompetensi dan Literasi Sekolah Menengah (PKLSM)*, also known as Assessment for Competency and Literacy in Secondary School, involves Form One and Form Two students from 297 secondary schools throughout the country was carried out. This assessment was conducted to assess the mastery level of higher-order thinking skills and evaluate students' readiness to deal with international assessments. Based on PKLSM 2019, the average score obtained by the participants for mathematics literacy shows a sharp decline from 372 in 2018 to 322 in 2018, respectively. According to the report, students could only solve questions in the ordinary context provided with clear information. Furthermore, students could only determine the information and perform routine calculations based on the given instructions and stimulus (Education Performance and Delivery Unit (PADU), 2020). Unfortunately, this shows that students have yet to achieve the competency level of higher-order thinking skills in mathematics and thus need attention to improvise.

In addition, the Trends in International Mathematics and Science Studies (TIMSS) 2019 results also show a decline in the average score of Malaysian Form Two students in Mathematics assessment from 465 in 2015 to 461 in 2019. Despite the insignificant downward trend of mathematics scores, the dropping number is below the median international score of 500 (Educational Planning and Research Division (EPRD), 2020). Table 1.1 shows the average score by Malaysian students in both the content domain and cognitive domain in Mathematics based on TIMSS 2019.

Table 1.1

Average Score in Content Domain and Cognitive Domain in TIMSS 2019

<table>
<tr><th>Rank</th><th>Domain</th><th colspan="4">Average score</th></tr>
<tr><td rowspan="4">Malaysia #28</td><td rowspan="2">Content domain</td><td>Number</td><td>Algebra</td><td>Geometry</td><td>Data and Probability</td></tr>
<tr><td>458</td><td>456</td><td>466</td><td>457</td></tr>
<tr><td rowspan="2">Cognitive domain</td><td>Knowledge</td><td colspan="2">Application</td><td>Reasoning</td></tr>
<tr><td>451</td><td colspan="2">464</td><td>462</td></tr>
</table>

Note. Malaysia's overall mathematics average score = 461, International median score = 500. Adapted from *Laporan Kebangsaan TIMSS 2019* Trends in International Mathematics and Science Study by EPRD, 2020. p.36.

Based on the result mentioned above, Malaysian Form Two students obtained the least average score for the content domain of algebra (456), which is lower than the intermediate international benchmark point compared to the other domains in the assessment (EPRD, 2020). The content area of algebra covers 30% of the mathematics assessment and is divided into two topic areas which are (1) expressions, operations, and equations (20%) and (2) relationships and functions (10%). This ratio shows that the algebra domain holds a very significant weightage in the overall scores in TIMSS. However, the low performance of the Form Two students in this domain causes the overall score in the mathematics domain to drop collectively. Moreover, the average score obtained for the cognitive domain is also below average for the domain of knowledge (451), application (464) and reasoning (462). The scores imply that Malaysian Form Two students' ability to use algebraic models to solve real-world problems and explain relationships involving algebraic concepts is insufficient for learning mathematics. Hence, an in-depth study needs to be carried out to identify the cause of the deficiencies and improve the mastery level of Form Two students, specifically in algebra.

Next, the second critical issue highlighted in the literature is students' difficulties in learning mathematics. According to Nor'ain et al. (2015), students need conceptual knowledge in learning as a pre-requisite to attempt problem-solving questions in mathematics. However, studies found that Malaysian students generally lack conceptual knowledge in mathematics (Hutkemri & Sharifah Norul Akmar, 2017). The lack of problem-solving and higher-order thinking skills hinder their ability to relate to and apply knowledge in new situations (Dorothy et al., 2016). Furthermore, students' internal factors, such as incorrect prior knowledge, unequal learning capabilities and the fear of making mistakes, negatively influence conducting an inquiry activity (Shao, 2018). Thus, students can rarely be active or independent throughout their learning process (Davies, 2019; Sze, 2019).

In the context of learning algebra, recent local studies show that students still face difficulties and misconceptions in learning this domain. A study by Md Yusoff and Ainun Syakirah (2019) stated that students make common errors related to procedural skills involving algebraic expressions and equations, factorisation and algebraic fractions. Similarly, Nur Alwani and Mohd Faizal Nizam Lee (2021) stated that reviews show that students struggle to solve algebraic fractions and are often confused with using variables in algebra. Next, a study by Saundarajan et al. (2020) highlighted that students struggle with algebraic computations involving constants and variables. Meanwhile, a study by Teh et al. (2020) states that teachers agree that students are having difficulties remembering conceptual and procedural knowledge in algebra topics. This problem further led teachers to encounter difficulties and a lack of confidence in delivering the contents of algebra due to the incompetency of students in mastering the topic (Foo et al., 2021). Furthermore, Mazlini and Nurul Sarah (2016) found that even high-performing students face difficulties solving non-routine algebraic problems.

Likewise, the need analysis done by the researcher in the Analysis stage of the module development reveals that teachers highly agreed that students face multiple difficulties in learning algebra in addition to those stated above. These difficulties include misinterpreting algebraic statements, difficulties in identifying variables, and difficulties in reasoning, analysing and relating algebraic terms. The findings also show that 91.0% of teachers agreed that the topic of Factorisation and Algebraic Fractions in Form Two mathematics is the most challenging topic to be mastered by the student. The mastery of this topic is crucial as it consists of basic knowledge of algebraic computations interconnected to almost all the other domains in mathematics. Thus, studies focusing on improving the knowledge and competencies of students in algebra need to be continuously carried out to minimise the issues raised.

The third critical issue that needs to be given due attention is the students' lack of interest in learning mathematics. According to the teachers' survey in TIMSS 2019, 68% of Malaysian mathematics teachers agreed that classroom teaching is limited by the student's readiness to receive instructions (EPRD, 2020). The findings show that students' achievement in mathematics is affected by their readiness during the teaching and learning sessions. One of the factors affecting students' readiness to learn is a lack of interest in mathematics (EPRD, 2020). Previous studies showed that interest in mathematics is significantly correlated with performance in mathematics (Noor Erma & Leong, 2014; Sirait, 2016). Students who lack interest in mathematics showed poor achievement in mathematics (Anigbo & Idigo, 2016). Lack of interest in mathematics also hinders students from actively engaging in learning and further causes difficulties in coping with higher-level mathematics (Acharya, 2017; Lan & Affero, 2016).

Previous research on interest has suggested that individual interest is appraised by value, knowledge and emotions (Krapp et al. 1992). These constructs can be measured by the degree to which a student exhibits a positive attraction (positive valence), negative experience (negative valence) or efforts and duration (time) spent on a particular subject matter (Steven & Olivarez, 2005). Hence, according to Steven and Olivarez (2005), a student with a high positive valence will be more likely to develop value towards learning. Meanwhile, a student with low negative valence will experience positive emotions towards mathematics. Subsequently, a student who commits more time to mathematics will develop a more significant amount of mathematical knowledge. A study done by Anigbo and Idigo (2016) on the factors affecting students' interest in mathematics found that instructional strategies adopted by teachers are the most substantial factor influencing students' interest in mathematics. Similarly, Mohd Zamri and Mustafa (2018) agreed that conventional teaching approaches such as classroom lectures and drilling practices have demotivated students in learning algebra and further caused boredom and losing interest in mathematics.

Hence, the use of an effective instructional strategy is one of the prominent concerns in learning mathematics. The current shift to student-centred learning led to a change in teachers' roles from knowledge transmitters to learning facilitators (Cuesta, 2010). Teachers should equip themselves with good content knowledge and content delivery strategies following the change in global education demand (König et al., 2020). Unfortunately, there are issues related to instructional strategies have been raised recently. It is reported that teachers have difficulties implementing 21st-century learning strategies due to the difference in students' pre-requisite knowledge, interest, motivation and learning style (Norazlin & Siti Rahaimah, 2019). In view of this, teachers have to spend more time facilitating the weaker students, and delivering all the learning outcomes in a particular lesson could be challenging.

Hence, as a measure to solve these issues, technology integration is seen as a viable option. Using technology in teaching and learning, teachers can implement differentiated instructions suitable to students' unique needs and learning abilities (Hanımoğlu, 2018). Moreover, integrating technology in mathematics will ensure that students engage in an active learning environment (Garba et al., 2015). On top of that, previous studies also show that technology integration positively impacts learning algebra (Saundarajan et al., 2020; Sun-Lin & Chiou, 2019; Azura & Siti Mistima, 2020).

On the other hand, modular learning has been gaining attention as an alternative approach being used widely in teaching and learning many subjects (Mohd Afiffi, 2010; Amani, 2014; Noor Azimah, 2019; Zainuddin et al., 2014; Siti Nabila et al., 2019; Muhamad Shakir et al., 2018). The use of learning modules not only inculcated self-directed and independent learning among students but also allowed students to learn at their own pace (Tee et al., 2013). Furthermore, using modules in teaching and learning enables teachers to plan systematic learning activities and increase their pedagogical skills in delivering content (Mohd Afifi Bahurudin et al., 2017). On top of that, modular learning has also been reported to positively affect students' achievement in mathematics (Annur Ashikin, 2018) and improve enthusiasm for learning (Mohd Faiq et al., 2018).

In line with that, implementing modular learning with technology integration, specifically the mobile-learning module will be viable to accommodate the shortcomings in conventional instructional strategy and students' learning needs in an active setting. The portability of mobile devices ensures that teachers and students engage in learning effectively from anywhere at any time (Nikolopoulou, 2018). In addition, the dynamic features of mobile devices, which support the use of various educational digital tools, will also enhance the learning experience for students (Ismaili & Ibrahimi, 2017). Moreover, the mobile-learning module will encourage students to engage in personalised learning at their own pace (Dissanayake & Velananda, 2020). Based on the need analysis done by the researcher, it is also found that teachers have a high level of agreement for implementing a mobile-learning module as an alternative to overcome the shortcomings in instructional strategy and learning environment for students.

Therefore, considering all these critical issues, it is inevitable that there is an urgent necessity to implement a mobile-learning module that could facilitate teachers and students in learning algebra. Thus, this study attempts to develop a mobile-learning module for the topic of Factorisation and Algebraic Fractions in Form Two Mathematics and evaluate its effect on students' achievement and interest in algebra.

1.4 Research Purpose

This research aimed to develop the Factorisation and Algebraic Fraction Mobile-learning (FAM) module for Form Two Mathematics based on the ADDIE instructional design model. Apart from that, this study also evaluates the effect of using the module on students' achievement in Factorisation and Algebraic Fraction and interest in algebra among students compared to the conventional learning approach. This research also determined the relationship between students' achievement in Factorisation and Algebraic Fractions and interest in learning algebra.

1.5 Research Objective

The objectives of this research are as follows:

i. To determine the need to develop a mobile-learning module for the algebra topics in Form Two Mathematics.

ii. To develop a mobile-learning module, namely the Factorisation and Algebraic Fractions Mobile-learning (FAM) module for Form Two Mathematics, with good validity.

iii. To evaluate the effect of the FAM module and conventional teaching on students' achievement in the topic of Factorisation and Algebraic Fractions in Form Two Mathematics.

iv. To evaluate the effect of the FAM module and conventional teaching on students' interest in algebra.

v. To evaluate the relationship between students' achievement in Factorisation and Algebraic Fractions post-test and interest in algebra.

1.6 Research Questions

Based on the objectives of the research, this study focuses on answering the following research questions:

i. Is there a need to develop a mobile-learning module for the algebra topics?

ii. Does the FAM module have good validity based on expert consensus?

iii. Is there a significant difference in the mean score for Factorisation and Algebraic Fractions pre-test between the control and treatment groups?

iv. Is there a significant difference in the mean score for Factorisation and Algebraic Fractions post-test between the control and treatment groups?

v. Is there a significant difference in the mean score between the Factorisation and Algebraic Fractions pre-test and post-test of the control group?

vi. Is there a significant difference in the mean score between the Factorisation and Algebraic Fractions pre-test and post-test of the treatment group?

vii. Is there a significant difference in the interest between the control and treatment groups after using the conventional approach and the FAM module, respectively?

viii. Is there a significant relationship between students' achievement in Factorisation and Algebraic Fractions post-test and interest in learning algebra?

1.7 Research Hypotheses

The followings are the research hypotheses for this study:

H_{01}: There is no significant difference in the mean score of the Factorisation and Algebraic Fractions pre-test between the control and treatment groups.

H_{02}: There is no significant difference in the mean score of the Factorisation and Algebraic Fractions post-test between the control and treatment groups.

H_{03}: There is no significant difference in the mean score between the Factorisation and Algebraic Fractions pre-test and post-test of the control group.

H_{04}: There is no significant difference in the mean score between the Factorisation and Algebraic Fractions pre-test and post-test of the treatment group.

H_{05}: There is no significant difference in the three constructs of interest (positive valence, negative valence, and time) between the control and treatment groups after using the conventional approach and the FAM module, respectively.

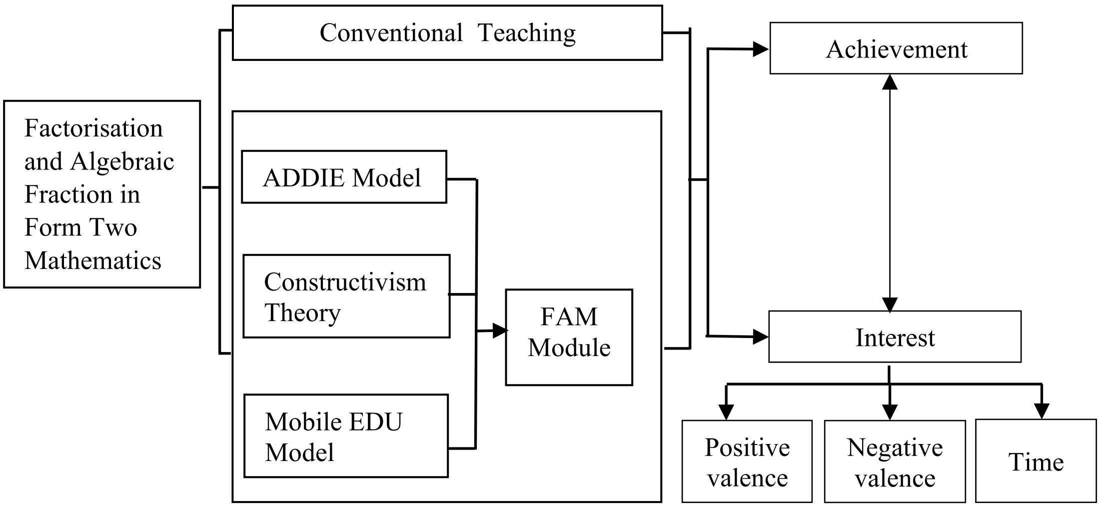
H_{06}: There is no significant relationship between students' achievement in Factorisation and Algebraic Fractions post-test and interest in learning algebra.

1.8 Conceptual Framework

This study is carried out to develop a mobile-learning module for the Factorisation and Algebraic Fractions chapter in Form Two Mathematics. The conceptual framework illustrated in Figure 1.1 shows the underpinning theories and models used to develop the FAM module and further evaluate its effect on students' achievement and interest in algebra.

Figure 1.1

Conceptual Framework of Study



The first dimension in this framework shows the topic of concern under the domain of algebra which will be used to develop the FAM Module. The second dimension in the framework shows two teaching and learning approaches that will be used to teach the Factorisation and Algebraic Fractions topic. Firstly, the conventional teaching and learning which uses textbook and lecture approach, and secondly teaching and learning using the FAM Module. This dimension also shows the models and theory used in designing and developing the FAM Module. The ADDIE instructional design model is the underpinning framework for the development of the FAM module. The ADDIE model consists of five stages that are (i) Analyse, (ii) Design, (iii) Develop, (iv) Implement and (v) Evaluate. This model is chosen due to its generic framework suitable for developing instructional materials integrating technology (Aldoobie, 2015). Meanwhile, the constructivism theory is used as the foundation for planning the instructional activity and the educational technology tool that has been implemented in the module. This theory believes that learners can construct knowledge based on personal experiences and social interaction with peers during the learning process (Liu & Matthews, 2005). Thus, the learning activities in the FAM module were developed to be used independently or in a group. This method gives students the flexibility to learn at their own pace and abilities.

Next, this study also employed the Mobile EDU Model by Muhammad Nidzam (2016) as the underpinning model for designing the components of the FAM module. These components include learning objectives, contents, applications, hardware, teaching and learning strategies, learning activities, evaluation methods, and opportunities suitable for implementing the FAM module. The third dimension of the framework shows the quasi-experimental study done to evaluate the effect of both approaches on students' achievement in the Factorisation and Algebraic Fractions topic and interest in learning algebra which is divided into three constructs, namely positive valence, negative valence and time. The study also determined the relationship between students' achievement in Factorisation and Algebraic Fractions and interest in learning algebra.

1.9 Significance of Study

Mobile learning is regarded as an evolution in the field of education. Although it is not something new, the implementation of mobile learning in the context of secondary school education in Malaysia, specifically in mathematics, is still at the infant level. However, there has been a significant surge in the use of online learning lately due to the COVID-19 pandemic worldwide. The closure of schools due to this pandemic has opened a new horizon for teaching and learning to be implemented remotely on a digital platform. As such, mobile learning is seen as one of the practical learning methods to ensure the continuity of learning during a pandemic (Muhammad Ridhuan Tony Lim & Saedah, 2010). Thus, this study attempts to develop a mobile-learning module for the topics of Factorisation and Algebraic Fraction in Form Two Mathematics, integrated with educational technology tools suitable for secondary school mathematics such as interactive video lessons, online quizzes, games, and bite-size notes. The result of this study potentially benefits several stakeholders in education, such as students, teachers, the Ministry of Education, and future researchers.

Firstly, this module is expected to promote personalised learning suitable to students' needs and abilities. Students will have flexibility in time and pace in using the mobile-learning module to prepare themselves before their in-class activities. This module is also expected to develop a strong understanding of conceptual and procedural knowledge and minimise misconceptions in the topics of Factorisation and Algebraic Fractions in Form Two Mathematics. Students' improved understanding of the topics will allow them to think critically and apply problem-solving skills in learning Mathematics. Apart from that, the interactive features of this module will engage students actively in learning, thus improving their interest in mathematics.

This study will provide an alternative method for teachers to apply technology-integrated teaching and learning strategies for the topics of Factorisation and Algebraic Fractions in Form Two Mathematics. By using this module, teachers will be able to improve their competencies in technological, pedagogical and content knowledge (TPACK). Implementing this module will save instructional time as students will be more prepared beforehand. Thus, teachers will have more time to focus on students' weaknesses or even misconceptions and attempt to rectify them during classroom discussion. Moreover, this study will provide a framework for teachers to plan more learning activities using mobile-learning modules for other topics in Mathematics according to students' needs.

The finding of this study is also expected to assist the Malaysian Ministry of Education in determining the effect of a mobile-learning module in teaching and learning at the secondary school level generally and in mathematics specifically. This study will provide vital information such as outline planning, content organisation and suitable assessments, which can be implemented in mobile-learning modules for other subjects and levels accordingly. The ministry could also plan appropriate professional development training for teachers to improve their knowledge in technology-integrated learning.

There is a growing interest shown by researchers worldwide focusing on various learning approaches. Therefore, the result of this study could provide an empirical explanation of the effectiveness of mobile learning modules for mathematics in a secondary school context. This study will also contribute to the pool of knowledge by suggesting a different potential area of study for the upcoming researchers in the field of education, focusing on developing technology-integrated teaching and learning material.

1.10 Limitations of The Study

This study has several limitations set to ease in conducting the research. Firstly, this study will be carried out in the state of the Federal Territory of Kuala Lumpur in a randomly selected district. The study population is all Form Two students in a national secondary school in the Federal Territory of Kuala Lumpur. Meanwhile, the sample unit consists of two intact groups of students from this population. This population is chosen based on the participation category in the international assessment, TIMSS and PISA, and the feasibility of implementing successful mobile learning. This is because the Federal Territory of Kuala Lumpur has reported a massive increase in the broadband and mobile device penetration rate compared to other states in Malaysia (MCMC, 2016). This measure will ensure that the students will most likely own a mobile device with a stable internet connection to support the mobile-learning environment.

This study is also limited to one particular topic in KSSM Mathematics for Form Two: Factorisation and Algebraic Fractions. This topic is chosen based on findings of the need analysis survey carried out by the researcher, which shows there is a high level of agreement among mathematics teachers on the difficulty faced by Form Two students in learning this topic. This selection is also supported by the findings from the TIMSS 2019 assessment, which reported that Malaysian students obtained the lowest score in the domain of algebra (EPRD, 2020). Furthermore, past studies also indicate the difficulties of learning the concepts related to this topic (Nur Alwani & Mohd Faizal Nizam Lee, 2021; Md Yusoff & Ainun Syakirah, 2019; Saundarajan et al., 2020; Teh et al., 2020). Therefore, the outcome of this research could not be generalized to all the topics in Form Two Mathematics or other subjects with different learning outcomes.

Furthermore, the instruments used for the need analysis, module validation, module evaluation, module reliability, and interest in algebra are self-reported questionnaires. Thus, the collected data were based on the samples' perceptions throughout the research. The samples were reminded that there were no correct or incorrect answers in the questionnaire. Thus, it is assumed that the data collected were unbiased and represented the actual perception of the samples.

1.11 Operational Definition

Several variables in this study have been identified to be defined operationally according to the context of this research.

1.11.1 Mobile-learning Module

Sidek and Jamaludin (2005) defined a module as a teaching and learning unit which discusses a particular topic systematically and orderly to assist the students to learn independently in order to master the learning unit quickly and precisely. Meanwhile, Crompton (2013) defines mobile learning as using personal electronic devices to learn across multiple contexts through social and content interactions. Thus, in this research, a mobile-learning module is defined as a learning module that can be accessed using portable devices such as smartphones, tablet PC, iPad, and netbooks computers.

1.11.2 Factorisation and Algebraic Fractions

Factorisation and Algebraic Fractions in this study refer to one of the topics covered in Form Two Mathematics. This topic belongs to the learning area of Relationship and Algebra in the KSSM syllabus. There are three content standards in this topic, namely (i) Expansion, (ii) Factorisation, and (iii) Algebraic Expressions and Laws of Basic Arithmetic Operation (MOE, 2016).

1.11.3 Effectiveness

Effectiveness can be defined as the degree to which an objective of a program is achieved (Productivity Commission, 2013, p.6). In this study, effectiveness is measured by comparing the mean achievement score and the interest score obtained by both the control and treatment groups after using the conventional approach and the FAM module, respectively, for the topic of Factorisation and Algebraic Fraction in Form Two Mathematics.

1.11.4 Achievement

Rafiola et al. (2020) stated that achievement results from an activity that can be created, carried out and pleased, obtained by working hard, individually and in groups. Furthermore, Rafiola et al. (2020) also defined learning achievement as a result of making an assessment expressed by numbers or symbols, where all that is about the progress of student learning outcomes during a specific period. In this study, achievement refers to the scores obtained by the students in the pre-test and post-test carried out during the evaluation phase for both the control and treatment groups. Each multiple-choice item answered correctly will be awarded one mark. Meanwhile, the marks for the structured items range from one to five. The score obtained by each student will be evaluated by using the formulae in Figure 1.2.

Figure 1.2

Formulae of Total Score of Achievement

$$\text{Total score} = \frac{A + B}{40} \times 100\ \%$$

Note. A = total mark obtained for the multiple-choice item, B = total marks obtained for the structured item.

1.11.5 Pre-test and Post-test

In this study, pre-test and post-test refer to the test carried out using the Factorisation and Algebraic Fraction Test (FAFT) to measure the knowledge acquired by the students from the control and treatment groups. The pre-test is the test conducted before the students in the control group undergo the conventional teaching and the treatment group undergoes the learning activity using the FAM module. Meanwhile, the post-test is conducted after the students in the control group undergo the conventional teaching and the treatment group undergoes the learning activity using the FAM module. The

Factorisation and Algebraic Fractions Test (FAFT) consists of ten multiple-choice items and five structured items adapted from past-year TIMSS and Form Three Assessment (PT3) trial papers. The questions chosen are based on the learning standard specified in the *Dokumen Standard Kurikulum dan Pentaksiran* (*DSKP*) for Form Two Mathematics (MOE, 2016) and the cognitive domain assessed in the TIMSS assessment, namely knowledge, application and reasoning (EPRD, 2020).

1.11.6 Interest

According to Hidi and Renninger (2006), interest refers to a psychological state of engaging or the tendency to re-engage with a specific object, activity or idea over time. In this study, interest refers to students' affective state of being engaged in mathematics learning after using the conventional approach by the control group and the FAM module by the treatment group for the topic of Factorisation and Algebraic Fractions in Form Two Mathematics. The students' interests will be measured using the Mathematics Interest Inventory (MII) adapted from Stevens and Olivárez (2005). This inventory consists of 27 items in a four-point Likert scale assessing three constructs, namely (i) positive valence, (ii) negative valence, and (iii) time. Positive valence refers to the tendency to be drawn toward learning algebra. Negative valence refers to the negative experiences that result in avoiding algebra. Meanwhile, the time factor refers to the time and effort one spends on algebraic-related tasks.

1.12 Summary

In this chapter, the study background focuses on current mathematics education and the teaching and learning practices. It also underlined several related problems and critical issues, which draws this study's attention. Based on the critical issues, the background theory and models were mapped into a conceptual framework. Then, the research purpose, objective, questions and hypotheses were distinguished. This is followed by a discussion of the importance of the research, its limitations and finally, the operational definition of the terms involved in the study.