DEVELOPMENT OF MOTION VIRTUAL LABORATORY (MoViL) MODULE AND ITS EFFECT ON THE ACHIEVEMENT IN THE TOPIC OF SPEED AND ACCELERATION AMONG FORM TWO STUDENTS

ASMAHWATI BINTI ROSLI

UNIVERSITI SAINS MALAYSIA

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by

ASMAHWATI BINTI ROSLI

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LIST ABBREVIATIONS

DDR	Design and Development Research
FDM	Fuzzy Delphi Method
KSSM	Kurikulum Standard Sekolah Menengah
MOE	Ministry of Education
MOVIL	Motion Virtual Laboratory

LIST OF APPENDICES

PEMBANGUNAN MODUL MAKMAL MAYA GERAKAN (MOVIL) DAN KESANNYA KE ATAS PENCAPAIAN DALAM TOPIK LAJU DAN PECUTAN DALAM KALANGAN PELAJAR TINGKATAN DUA

ABSTRAK

Kajian ini bertujuan untuk membangunkan modul makmal maya gerakan (MoViL) mengenai topik laju dan pecutan bagi pelajar tingkatan dua. Metodologi Kajian Reka Bentuk dan Pembangunan seperti yang diperkenalkan oleh Richie dan Klein (2007) digunakan dalam kajian ini yang melibatkan tiga fasa. Data fasa pertama iaitu analisis keperluan telah dikumpul melalui temu bual separa berstruktur dengan 6 orang pakar dan soal selidik yang ditadbirkan ke atas 90 orang pelajar tingkatan dua. Data dianalisis menggunakan perisian *Statistical Packages for the Social Sciences (SPSS) version 26*. Dapatan bahagian pertama dalam fasa kedua, reka bentuk modul diperoleh melalui Kaedah Fuzzy Delphi yang melibatkan 15 orang pakar Kurikulum Matematik, Bahasa, dan Teknologi Pengajaran. Analisis bergantung kepada maklum balas pakar terhadap soal selidik berdasarkan Skala Likert Linguistik Fuzzy. Nilai ambang d dikira untuk menentukan konsensus pakar ke atas semua item soal selidik. Data bahagian kedua fasa kedua iaitu pembangunan modul melibatkan pemurnian rancangan pengajaran dan bahan pembelajaran dengan pengesahan tiga orang pakar. Pada fasa ketiga, keberkesanan modul telah diuji menggunakan reka bentuk kuasi eksperimen. Perbandingan pencapaian antara kumpulan rawatan dan kawalan dijalankan berdasarkan keputusan ujian pra, pasca dan pengekalan. Dapatan fasa pertama mengenal pasti (i) keperluan modul yang sesuai untuk guru melakukan pengajaran dan pembelajaran bilik darjah terbalik bagi matematik pelajar tingkatan dua dan pengetahuan pelajar tentang topik laju dan pecutan, (ii) strategi pengajaran

yang sering digunakan oleh guru semasa pengajaran dan pembelajaran dan (iii) gaya pembelajaran pelajar. Dapatan bahagian pertama dalam fasa kedua, reka bentuk modul, mendedahkan bahawa pakar telah mencapai konsensus sebulat suara dengan nilai ambang $d \leqslant 0.2$, melebihi 75% pada kesesuaian item dalam modul pembelajaran. Dapatan bahagian kedua dalam fasa kedua pembangunan modul mencadangkan beberapa penambahbaikan, terutamanya mengenai penggunaan video dan kuiz. Dalam fasa ketiga, penilaian modul, dua kumpulan pelajar terlibat dalam kajian iaitu kumpulan eksperimen (modul MoViL) (n=30) dan kumpulan kawalan (kaedah konvensional) (n=30). Pencapaian pelajar dianalisis menggunakan skor min ujian pra, ujian pasca, dan ujian pengekalan. Dapatan utama menunjukkan bahawa skor min pelajar yang didedahkan dengan modul MoViL yang baru dibangunkan adalah lebih tinggi secara signifikan berbanding pelajar yang didedahkan kepada kaedah konvensional dalam ujian pasca dengan t (58) = 3.38, p < .05. Keputusan daripada ujian pengekalan juga mendedahkan bahawa modul MoViL bukan sahaja meningkatkan pemahaman konsep pelajar tetapi juga mengekalkan ingatan pelajar lebih lama berbanding kumpulan kawalan dengan t (42.65) = 12.74, p < .05. Ini menunjukkan bahawa modul makmal maya gerakan (MoViL) berkesan dalam meningkatkan keupayaan pelajar untuk menghubungkan kemahiran dan pengetahuan. Oleh itu, modul tersebut sebagai garis panduan boleh memberi manfaat kepada guru dalam merancang langkah-langkah yang akan diambil dalam kurikulum Matematik.

DEVELOPMENT OF MOTION VIRTUAL LABORATORY (MOVIL) MODULE AND ITS EFFECT ON THE ACHIEVEMENT IN THE TOPIC OF SPEED AND ACCELERATION AMONG FORM TWO STUDENTS

ABSTRACT

This study aimed at developing the Motion Virtual Laboratory (MoViL) module on the topic of speed and acceleration for form two students. The Design and Development Research methodology as introduced by Richie and Klein (2007) was used in this study involving three phases. Data from the first phase, the need analysis, were collected through the semi-structured interview with 6 experts and questionnaire administered on 90 form two students. The data were analyzed using the Statistical Packages for the Social Sciences (SPSS) version 26. The findings of the first part in the second phase, the module design was obtained through the Fuzzy Delphi Method involving 15 experts in Mathematics Curriculum, Languages, and Instructional Technology. The analysis relied on the experts' reponses to the questionnaire based on a Fuzzy Linguistic Likert Scale. The threshold d value was calculated to determine the experts' consensus on all questionnaire items. The data of the second part in second phase, the module development, involved refinement of lesson plans and learning materials with validation by three experts. In third phase, the module effectiveness was tested using quasi-experimental design. The comparison of achievements between the treatment and control group was conducted based on the pre-test, post-test and retention-test results. The findings of the first phase identify (i) appropriate module requirements for teachers to do teaching and learning for mathematics of form two students and students' knowledge of topic speed and acceleration, (ii) teaching strategy that is often used by teachers during teaching and learning and (iii) student learning style. The findings of the first part in second phase, the module design, revealed that experts have achieve unanimous consensus with the threshold d value ≤ 0.2, exceeded 75% on the suitability of items in the learning module. The findings of the second part in the second phase of module development suggested a number of improvisations, especially on the use of video and quiz. In third phase, the module evaluation, two groups of students were involved in the study, namely experimental group (MoViL module) (n=30) and control group (conventional method) (n=30). Students' achievement was analysed using the mean score of pre-test, post-test, and retention-test. The main findings show that the mean scores of students who were exposed to newly developed MoViL module are significantly higher than students who were exposed to conventional method in post-test with $t\ (58) = 3.38$, $p < .05$. The results from retention-test also revealed that MoViL module has not just enhanced students' conceptual understanding but also retained students' memory longer compared to control group with $t\ (42.65) = 12.74$, $p < .05$. This indicated that Motion Virtual Laboratory (MoViL) module was effective in improving students' ability to link skills and knowledge. Hence, the module as guideline could benefit teacher in planning steps to be taken in Mathematics curriculum.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

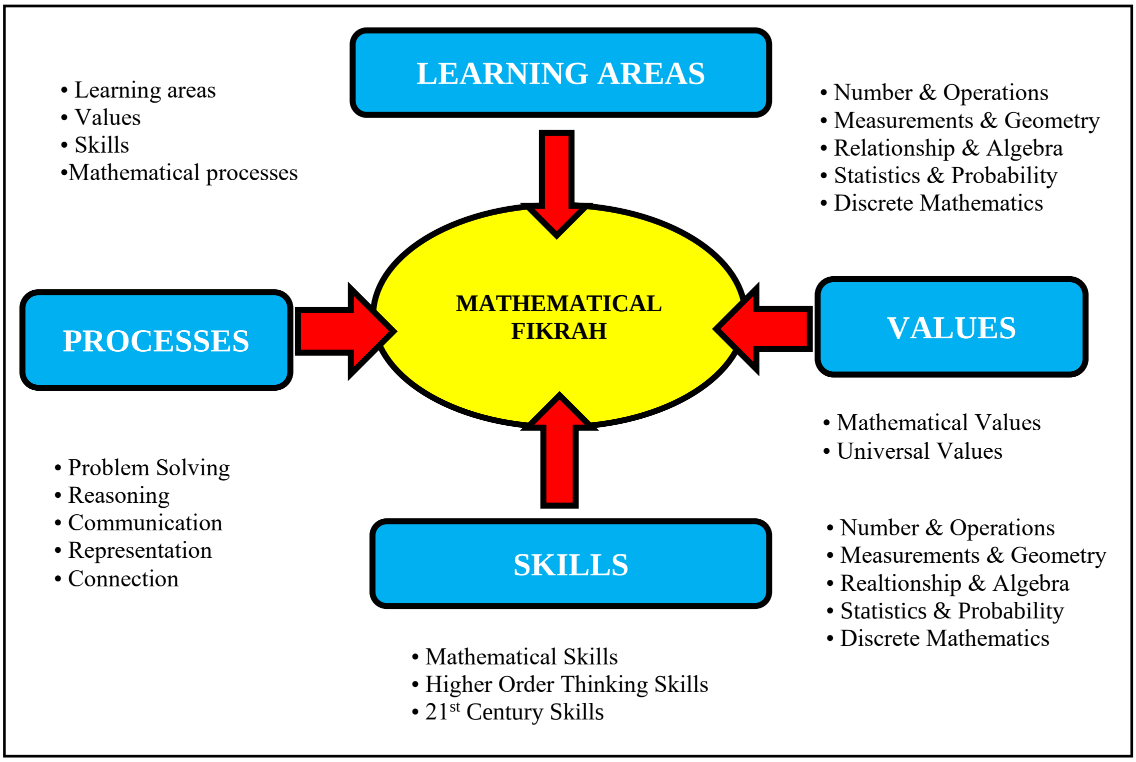
Malaysia's education system is built on a centralised administrative structure (Abdullah & Asraf, 2017; Hussein, 2014; Hussin, 2017; Paramasivam, 2018; Rao & Jani, 2011; Zamrus & Mokelas, 2000). This means that the Ministry of Education Malaysia (MOEM) is in charge of all education policy choices. The schools exclusively follow orders from MOEM's many departments, such as the Curriculum Development Division (BPK in Malay), the Textbook Division, the State Education Department (JPN in Malay), and the District Education Office (PPD, being its acronym in the Malay language). BPK is in charge of developing and distributing the curriculum, as well as providing training and resources.

In 2017, the Secondary School Standard-Based Curriculum (KSSM, as it is known in Malay) was implemented. Rearrangement of Mathematics KSSM takes into account the transition from primary to secondary school and then to a higher level. In addition, Malaysia's Mathematics Curriculum has been compared to that of high-performing countries in international assessments. This measure is intended to guarantee that Malaysia's mathematics curriculum is current and comparable to that of other countries throughout the world. Mathematics is the finest medium for developing an individual's potential, intellectual competency, and human capital since it stimulates logical and methodical thinking. As a result, the mathematics curriculum is being developed with the needs of the growing country in mind, as well as factors that contribute to the development of individuals who can think logically, critically, analytically, creatively, and innovatively (García-García & Dolores-Flores, 2018, 2019). This is in line with the requirement to ensure that the country has appropriate mathematical knowledge and abilities in order to compete internationally and meet the challenges of the twenty-first century. When determining the knowledge and skills taught in the curriculum, careful consideration is given to the students' diverse knowledge and skills (MOE, 2017).

Mathematics KSSM focuses on developing individuals who internalise and practise mathematical fikrah. The Mathematics Curriculum Framework as illustrated in Figure 1.1, is fundamental to the implementation of the mathematics curriculum in the classroom. Four key elements that contribute to the development of human capital possessing mathematical fikrah are:

Figure 1.1

The Mathematics Curriculum Framework for Secondary Schools. Adapted by MOE (2017), Kurikulum Standard Sekolah Menengah Matematik Tingkatan 2 in page 5.



The Mathematics Curriculum Framework for Secondary Schools, like any other mathematics curriculum, can play a crucial role in the development of human capital possessing mathematical fikrah. The following are four key elements that can contribute to this development: Learning area: The curriculum framework should clearly define learning objectives for each mathematical topic and concept, to ensure that students are able to develop a comprehensive understanding of mathematical reasoning. Process: The curriculum framework should encourage the use of a variety of teaching approaches, such as hands-on activities, real-world applications, and problem-solving activities, to engage students in the learning process and foster their mathematical fikrah. Skills: The curriculum framework should include a range of assessment and evaluation methods, such as formative and summative assessments, to measure student understanding and progress in developing mathematical fikrah. Values: The curriculum framework should promote continuity and coherence between different mathematical topics and concepts, allowing students to build on their previous knowledge and skills to further develop their mathematical fikrah. By incorporating these key elements, the Mathematics Curriculum Framework for Secondary Schools can play a critical role in promoting the development of human capital possessing mathematical fikrah, which is essential for success in many fields and in daily life.

The problem of learning mathematics has been studied for decades and is often included as part of Science, Technology, Engineering, and Mathematics (STEM) education. Success in the education system relies on students' mastery of a range of important cognitive skills (MOE, 2013). As a result, students are expected to develop critical thinking skills, among other characteristics, in the 21st century education system. These characteristics include high self-esteem, self-directed learning, active participation, citizenship concerns, self-development, cultural internationalism and identity, communication and media skills, and a sense of responsibility towards nature to ensure a sustainable future (MOE, 2013).

Moreover, the evaluation process in mathematics education typically focuses on individual tasks, and students are encouraged to work independently. In traditional classrooms, however, students often collaborate (García-García & Dolores-Flores, 2019; Berry & Nyman, 2002). Consequently, students often work alone in mathematics, relying on textbooks and assigned materials. It is clear that the teacher, who possesses knowledge of the correct answers, asks the questions, and the students provide responses. The student may inquire if they do not understand something, while the teacher has undisputed authority to provide an answer or assist in finding the correct solution. Conventional teaching methods emphasize the solution or outcome of a problem more than the process of reaching it.

The topic of speed and acceleration is a fundamental course taught in Mathematics Form Two in KSSM. As the aim is to produce highly skilled and knowledgeable students, greater emphasis should be given to the learning experience of this course. This is because only 38 percent of students passed the final PT3 examination in 2019. According to Paxinou et al. (2020), students face difficulty in understanding basic concepts and real-world applications of this course. This difficulty can be attributed to the teaching methods used by teachers. The teaching and learning practices in schools emphasize a combination of hands-on and classroom learning, which helps in the application of comprehensive skills (Ali & Marwan, 2019; Boahin & Hofman, 2013). Such teaching practices can produce highly skilled students with advanced knowledge and skills.

The situation has worsened due to students often confusing speed and velocity, which focus solely on one-dimensional movements. Additionally, acceleration, being the second derivative of displacement, is a particularly challenging quantity that students often confuse with velocity. Even if students understand the difference, they may regard acceleration as an increase or decrease in speed, but frequently fail to recognize it as a vector quantity, which is further aggravated by the study of one-dimensional movements. Another prevalent misconception regarding motion is that an object's velocity must be maintained by applying force. This misconception must be corrected to the expert notion that a force is only required to modify an object's velocity (i.e., speed and/or direction of movement). Hast and Howe (2013) also reported difficulties in distinguishing between horizontal and descending motion.

Research has found that speed comparison questions, and consequently, relative speed and acceleration, can be quite challenging for students, leading to misconceptions (Trudel & Métoui, 2019; Trudel & Métoui, 2013; Rowlands et al., 2007). This study reveals that despite having identical views on speed and acceleration, students significantly struggle with these concepts, with the majority misunderstanding the topics (Trudel & Métoui, 2013). In the field of science education, understanding students' beliefs and views about various scientific phenomena is essential.

Information and communication technology (ICT) can be a comprehensive and inclusive tool for teaching and learning mathematics. Mathematics learning with ICT is the result of a combination of principles and strategies from the education and technology domains. As students constantly incorporate the use of ICT in their daily lives, it has huge potential to stimulate the learning process and broaden their thinking skills (Salleh & Ayudin, 2018). However, in Malaysia, the above-mentioned potential has not been fully realized. Poor mathematics achievement is becoming a recurring issue in secondary schools, as evidenced by declining scores for mathematics among PT3 candidates since 2015. Therefore, in Malaysia, various factors regarding the development of ICT-based mathematics teaching and learning framework guidelines need to be recognized. The framework guidelines will be based on the mathematics KSSM and could enhance international performance and mathematics proficiency.

A study conducted by Paniuga and Instance (2018) argues that factors contributing to student achievement include insufficient time to cover all teaching and learning content. Learning time involves the process of understanding and acquiring skills in a given learning context, and when there is not enough time available, this can hinder learning (Rowe et al., 2018). Lack of time spent learning in the classroom can be addressed by utilizing information and communication technology (ICT) as a solution (Rathner et al., 2020; Abah et al., 2017). Therefore, this study aims to integrate teaching and learning of speed and acceleration using information and communication technologies, as well as delivering hands-on learning. Kelly et al. (2017) also point out that students' knowledge and skills are aspects of improving student performance. However, inadequate classroom time contributes to a decline in student learning performance. Lozano (2017) argues that to obtain quality education for students that meets industry needs, the delivery methodology must be adapted to emphasize knowledge, problem-solving, and real-world experience in the technology and communication environment. Failure to adapt to this change will result in a decline in student learning performance (Radovic et al., 2017).

The issue is consistent with the findings of Hsu et al. (2017), which suggests that the integration of technology components in mathematics teaching and learning in Malaysia is highly relevant. The use of technology by students provides an opportunity to enhance their skills and knowledge, gain real-world experience, self-learn and save time in the classroom. Wang (2017) also described that online learning models using technology could improve students' knowledge through real-world experience. Moreover, online learning allows for the learning process to occur at any time (Wai & Seng, 2015). Considering today's social, economic, and technological changes, pedagogy needs to adopt a technology-driven approach (Siew-Eng et al., 2015). The application of technology in teaching will not only interest students but also have a significant impact on their learning. This is in line with the Malaysian Education Development Plan 2013-2025, which encourages the use of blended learning elements in teaching (Ministry of Education, 2013).

Online teaching strategies have proven to enhance student achievement, knowledge and skills (Sentence & Czismadia, 2017) emphasize the role of teachers in using technology in teaching in the classroom and beyond. This is also agreed by Sergis et al. (2018) who found that teachers have an important role in the usage of technology in the classroom. Teachers not only act as delivery agents but also act as facilitators or instructors in the teaching and learning process (Law et al., 2019).

Schools’ widespread access to ICT poses tremendous challenges to physics laboratory teaching and learning (Jimoyiannis & Komis, 2001). Many students are unable to effectively explain the key points of an experiment they have just finished. Typically, they recall some of their laboratory manipulations but are unable to explain the experiment's fundamental and actual purpose. They also don't find it especially intriguing or pleasurable to them (Reif & Mark, 1979). The majority of students' problem-solving approaches show that they have poor procedural understanding. According to the findings, conventional or conventional laboratory education is ineffective in addressing misconceptions. Students frequently mix up velocity with acceleration, or make comparisons between the two, and have significant difficulty using graphical representations of motion (Jimoyiannis & Komis, 2001). Mathematical physics connects mathematics to physical phenomena. Its tools allow us to describe how a top spin, how a pendulum swings or how a rattleback rocks and defies normal intuition. Studying mathematical physics reveals the hidden intricacies of relativity and quantum theory.

A blended learning strategy model using online technology can be delivered through a variety of approaches (Danker, 2015; Challob et al., 2016). One of the most recent learning strategies is the flipped classroom to implement blended learning methods based on online technology (Azlina et al., 2015). The flipped classroom approach enhances students' knowledge and performance for engineering and technology-based courses (Delozier & Rhodes, 2017; Lo et al., 2017). By that thus, students' performance, interest and knowledge of their learning will increase by using the classroom approach (Taotao et al., 2017; Gilboy et al., 2015).

The flipped classroom approach has been found to enhance students' knowledge and is particularly effective for mathematics, according to Lopes and Soares' (2017) research. This approach improves learning time and enhances student learning performance by delivering course content more effectively. Delozier and Rhodes (2017) support the idea that the flipped classroom method can solve the problem of class presentations and improve student performance and knowledge. To address the issue of students not being able to connect existing skills with real-world knowledge (Sumirattana et al., 2017), it is crucial to introduce reflective learning in the flipped classroom. The importance of reflective thinking is closely related to the development of professional competence in learning (Dewey, 1933; Wallace, 1991). Schön (1983) emphasizes that this concept trains students to think critically and consistently integrate existing and new information, encouraging them to think ahead. Therefore, by emphasizing the concept of reflective learning in the flipped classroom, we not only address the issues of time constraints and the effectiveness of teaching delivery quality but also help students better understand their learning content and its applications in the future.

Zin et al. (2012) reported a combination of many different types of media communications including text, graphics, audio, video, music, and animation. Multimedia and computational technologies are combined in interactive media (Eastman et al., 2011). This kind of technologies is relevant to be applied in the education field because it can help students to understand about the related topics.

Brown and Collins proposed design and development research in the 1990s, and it is now one of the most well-known approaches in educational research for testing theory and validating its applicability. The method is also known as developmental research, design research, design-based research, formative research, and design-cased, and it includes both conceptual and practical components of the 'what' and 'how' of 'doing' (Richie & Klein, 2007). This learning prototype aims to design, create, and integrate a kit learning application on the Tracker Software platform with the Motion Virtual Laboratory (MoViL) Module. It is designed to provide an interactive learning experience for pupils who have previously learned Mathematics via non-computer-based methods.

Design and development research, also known as design-based research, focuses on creating and testing a wide range of created innovations, including products, artefacts, and models, as well as less tangible components like programmes, activities, scaffolds, and curriculum. The fundamental purpose of the research is to provide instantiations or techniques for tackling human teaching and learning problems while also creating a set of design principles to guide future development efforts (Reeves, 2000).

Computers, which are the first thing that comes to mind when people think of technology, have now influenced nearly every part of life and changed human behaviour (Usta, 2011). In education, technology is employed for two major purposes: to improve the effectiveness of instruction and to integrate technology into the curriculum (Gulbahar et al., 2010). The use of computers in educational activities, as well as the implementation of new technology-based teaching strategies, leads to the creation of training organisation that is not achievable with conventional approaches. Computer processing, recording, and retrieval of information provide conditions in which students learn knowledge and skills independently, based on their own interests and objectives (Chandra & Watters, 2012).

Nowadays, the widespread use of Tracker, a computer simulation-based learning or virtual laboratory tool, has changed the conventional teaching approach, improved the teaching effect, and made the teaching procedure more vivid (Amoros et al., 2018). Technology is essential in the teaching and learning of mathematics as it has a significant impact on how mathematics is taught and learned, enhancing students' learning experience.

While students demonstrate projectile motion in class by tossing a ball or oscillating a basic pendulum, understanding the mathematical equations involved in projectile motion is difficult for them. Despite several attempts by teachers to incorporate hands-on activities such as real equipment, video analysis, or computer simulation into the understanding of projectile motion, some research continues to chronicle students' misconceptions or learning challenges (Hecht & Bertamini, 2000).

1.2 Statement of the Problem

Most of the current secondary school teaching and learning methods are quite conventional, with content-based models that require teachers to focus solely on the course syllabus, resulting in students only superficially learning the course material. Another reason why teachers must employ conventional teaching and learning processes is the limitation of class time (Lopes & Soares, 2017). The lack of in-depth learning in today's higher education system has resulted in misconceptions about students' low achievement levels. They often fail to apply the concepts they have learned via conventional methods. As a result, they are unable to grasp higher-level course material and eventually have difficulty adapting to new topics.

Many students face difficulties in achieving academic success, despite their efforts to do well in their studies. These difficulties can manifest in different forms, such as low grades, poor performance on exams, or difficulty completing assignments on time. Such academic struggles can lead to frustration, decreased motivation, and a sense of helplessness among students (Dineen & Boehnlein, 2010). The study suggests that interventions focused on helping students develop effective study skills and time management strategies can lead to significant improvements in academic achievement.

The factors that contribute to these difficulties in achievement can be diverse, ranging from personal factors such as a lack of motivation, low self-esteem, or anxiety, to external factors such as insufficient support from teachers or peers, inadequate resources, or a challenging academic environment (Eisenberg & Speer, 2013). The study suggests that providing students with mental health support and resources can help them manage stress and anxiety, which can, in turn, improve their academic achievement.

As academic achievement is crucial for students to achieve their future goals and success, it is important to understand the reasons behind these difficulties and develop effective strategies to help students overcome them. Therefore, identifying the root causes of students' academic struggles and finding ways to provide them with the necessary support and resources can help students achieve their full potential and reach their academic goals (Lee & Burkam, 2003). The study suggests that social support can help students develop a sense of belonging and connectedness, which can improve their motivation and academic achievement.

The decline in the TIMSS assessment, from an average score of 519 to 440 in 12 years, indicates that the teaching methods implemented by teachers are less effective in developing students' thinking skills. The cognitive domains of the TIMSS mathematical subjects include 35% knowledge, 40% applications, and 25% reading (Ministry of Education, 2012). The performance of students in TIMSS and PISA reflects their thinking skills. An analysis of the TIMSS 1999, TIMSS 2003, and TIMSS 2007 estimates found that the lack of self-confidence among students was one of the factors affecting their mathematical achievement (Noor Azina & Halimah, 2012). To address this issue, the Malaysian Ministry of Education has provided the PPPM and PPPM (PT) policies. One of the five aspirations of the Malaysian education system is to place the performance of national students in TIMSS and PISA tests at one-third of the top three groups within the next 15 years (Ministry of Education, 2013). Enhancing the quality of teaching and learning is one of the methods that can lead to the 10 surges in achieving the system aspirations and aspirations (Ministry of Education, 2015).

It is essential to emphasize that the teaching and learning methods commonly used by educators in developing countries do not adequately promote critical thinking skills among students. Instead, students are often asked to memorize facts or mathematical formulas (Richmond, 2007). Furthermore, many educators still rely on lecture-based instruction, individual training, and classroom discussions (Mariani & Zaleha, 2013; Koh et al., 2008; Yeo & Zhu, 2005). To achieve the country's mission and aspirations in this aspect, it is crucial to apply teaching strategies or methods that promote thinking skills. Unfortunately, teachers or lecturers often struggle to incorporate these elements into their teaching and learning strategies (Rahil et al., 2004). Rajendran's findings (2001) reveal that 103 out of 364 teachers lack confidence in applying thinking skills in teaching and learning. Similarly, Fani (2011) identifies teachers' inadequate training in teaching thinking skills as a significant constraint to students' development of such skills. Therefore, it is especially important to introduce teaching methods that incorporate thinking skills to future teachers. This is supported by Nooraini and Khairul Azmi (2014), who highlight the need to train teachers to master these teaching methods.

They are not prepared to implement the transformation, which is a basic issue (Mariani & Zaleha, 2013; Wan Nor Atiqah & Muzirah, 2016). It is necessary to provide them with training or an innovation implementation guide so that they can implement innovation in teaching and learning. The need to assist teachers in making this adjustment is critical (Rajendran, 2001). Various parties must also endorse this necessity (Sukiman et al., 2012). As a result, this may be overcome through the creation of an adventure-based teaching and learning training module that may be utilised as a teaching and learning guide. This is due to the fact that qualified teachers are unable to adopt this learning style (Carrier et al., 2013). Therefore, the impact testing of the implementation of Motion Virtual Laboratory (MoViL) Module is required so that research findings can be used as a guide in producing human capital as required.

In the learning process at school, mathematics is a subject that presents major challenges to students. Many students report difficulties in acquiring the knowledge and skills needed to excel in mathematics. This is because mathematics requires higher order thinking skills for problem-solving. Constructing or posing problems involves creating new challenges or questions to be examined in a given scenario (Cai & Ding, 2015; Cildir & Sezen, 2011). Therefore, mastery of mathematics knowledge and skills is crucial.

In a large-scale study by Chandra et al. (2012), Students may suggest interactive research models and draw specific conclusions using interactive models, which can be used effectively in learning. Students gain information through independent creative activity, and this knowledge is then applied to produce a tangible outcome that can be seen on a computer monitor. Moreover, learning styles in mathematics education is also a potential to improve this subject's instructional process and increase students' willingness to learn mathematics (Zajacova, 2013).

To address the challenges in Mathematics education, this study focuses on the design and development of the MoViL module to enhance students' learning in the speed and acceleration topic. Teachers often face challenges in developing and preparing alternative tools to teach, resulting in stereotyped instructional strategies (Rahman et al., 2018). The MoViL module is designed to enable students to think critically and creatively, articulate arguments for difficult concepts in mathematics, and solve mathematical problems successfully. It is also intended to provide students with easy access to information related to the topic. An effective module should consider how it can improve students' cognitive capacities while reducing their cognitive burden.

Speed and acceleration are topics covered in Mathematics for Form two students. Some students find these topics challenging to understand and require a strong connection to prior concepts and ideas (Jones, 1983; Cobern, 1996; Ng & Soo, 2006). The objective of designing this computer-based Motion Virtual Laboratory (MoViL) module is to facilitate a deeper understanding of two key aspects of motion: speed and acceleration, including their cause-and-effect relationship.

Common difficulties facing by students with topic on motion can be attributed to primary conceptual difficulties (Throwbridge & McDermott, 1981; Jones, 1983). The first difficulty is that students cannot relate the application of mathematics with their daily life experience. Meanwhile, the second conceptual difficulty is that students cannot use their common-sense problem related to the speed and acceleration. The conceptual difficulties faced by students are evident when teachers avoid superficial multiple-choice, short answer or recall questions in favour of assessment practices that truly get inside students' heads.

Many students struggle with retention, which refers to their ability to remember and recall information they have learned. Despite spending hours studying, some students find it difficult to retain information and often forget it soon after the exam is over. This can be frustrating for students and can lead to poor academic performance, which can affect their overall confidence and motivation (Freeman et al., 2014).

The issue of retention difficulty is not limited to a specific age group, academic level, or subject matter, but is a common problem faced by students at all levels of education. Some of the factors that contribute to this issue include the teaching methods, study habits, personal motivation, and attention span of students (Bangert-Drowns et al., 1991). Therefore, finding effective ways to help students improve their retention abilities can have a positive impact on their academic performance, overall confidence, and future success.

In relation to technology, students can explore teaching and learning process more effectively (Alias et al., 20214). The development of Motion Virtual Laboratory (MoViL) Module will help students in understanding the basic concept more conveniently. Thus, students with low achievement level can learn well because they can use more time on the module. Learning modules allow students to carry out their learning without being interrupted by other factors such as not able to record the notes during the formal class. Scientists also have used the concept of visualization of this advanced technology to unravel complex problems.

Content, format and presentation mode in this module were different from other multimedia modules because in this module it is combined with a variety of media from various sources for easy user access. Learning will be more effective without wasting time searching for web pages that are relevant to the topic of speed and acceleration. When students use a deep approach to their learning, they can get a higher education outcome such as critical thinking, problem solving and synthesize, compared to the surface approach to learning which will lead to lower-level results, such as using memorization techniques to simply pass an evaluation (DeWitt et al., 2016).

In-class collaborative learning through problem-solving activities is also recommended by Lecia et al. (2009) to increase student interest in class and reduce dropouts. To improve the effectiveness and enjoyment of classroom learning, the Motion Virtual Laboratory (MoViL) Module can be used. These modules explain concepts and issues in a visual format, allowing students to see and perform the actions required to solve the problem. The effectiveness of using the MoViL Module in a classroom environment will be studied, with the aim of making classroom teaching more appealing to teachers and students. To gauge student reactions, a number of questionnaires will be completed in the classroom as part of the research. A learning styles survey will also be conducted to determine the students' learning preferences.

The problem of the method of delivery is closely related to the time constraints of integrating industry elements in teaching and learning; this is in line with a study conducted by Paniuga and Instance (2018) who emphasized that there was insufficient time to cover all teaching and learning as well as the content of the course are among the factors of student achievement. Mathematics learning time involves the understanding and skill of a given learning environment and this makes learning time scarce (Rowe et al., 2018). Lack of time to spend learning in the classroom can be overcome by using information and communication technology as a solution (Rathner et al., 2020; Abah et al., 2017). Therefore, flipped classroom strategy is potentially implemented to address the problem of time constraints in the classroom with the use of information technology (Rowe et al., 2018; Abah et al., 2017).

The flipped classroom approach is one of the latest learning strategies to implement blended learning methods based on online technology (Azlina et al., 2015). The flipped classroom approach enhances students' knowledge and performance for engineering and technology-based courses (Delozier & Rhodes, 2017; Lo et al., 2017).

As a result, students' performance, interest and knowledge of their learning will be enhanced using the classroom approach (Beatty et al., 2019).

The flipped classroom approach enhances students' knowledge and is ideal for mathematics education. This is in line with the findings of Lopes and Soares (2017) that through flipped classroom approaches, learning time is enhanced as the content of the course can be delivered more effectively and thus improve student learning performance. (Delozier & Rhodes, 2017; Lo et al., 2017) support the notion that this method is capable addressing the problem of delivery time in the classroom further enhances student performance.

However, studies on the implementation of flipped classroom in Malaysia are very limited. The study by Zainuddin and Attaran (2016) explains the early exploration of the implementation of flipped classroom on the campus of University Malaya. This research discovered that in the early phases of flipped classroom implementation, learning English among university students due to the change in teacher-centred learning methods to student-centred learning. However, the problem occurred only at the beginning of the implementation of this method. Students' behaviour and performance towards learning is more positive and makes this flipped learning strategy a great platform for the process of developing knowledge, collaborative learning and saving time in the classroom. Therefore, implementing flipped classroom can increase knowledge and address the shortage of class presentations.

A qualitative study conducted on 24 undergraduate students at Universiti Sains Malaysia (USM) by Rozinah and Siti Zuraidah (2014) on the use of flipped classroom, showed an increase in students' active learning from behavioural, emotional, cognitive and student engagement levels in the class. The emotional impact of the students is very positive on the materials and methods of the flipped classroom as students are more interested in going to class, learning the latest learning methods, actively engaging and feeling learning in the classroom is now more interesting. While positive effects of student behaviour can be seen during teaching activities. Students listen carefully to the instructions, follow the instructions, and follow the activities in the classroom. According to the study, the implementation of this flipped calssroom is very well implemented in Malaysia by giving a whole new dimension to the classroom delivery method.

Recently, an exploratory case study conducted by Dorothy DeWitt et al. (2014) on 10 undergraduate students who took a research methodology course at the University of Malaya to find out students' perceptions of materials use, implementation and flipped classroom. The instructional materials used are PowerPoint slides as well as videos used before class begins. The findings show that students can learn better by using flipped classroom strategies using PowerPoint slides or video. In addition, students' knowledge and performance increased with the implementation of flipped classroom and students felt that using this strategy could save them time.

Based on the flipped classroom studies in Malaysia, it can be seen that this is a recent study. Although there are several studies of flipped classroom in Malaysia, studies on the development of modules for flipped classroom for secondary school are still lacking. In addition, the study methodology for flipped classroom in Malaysia is more focused on the study and also the early exploration of the implementation of the reverse class as a new strategy of learning and teaching. However, the development study methodology for this flipped classroom is still poorly used as the main research methodology.

Although flipped classroom methods have the potential to overcome time constraints in teaching at school, the key question that arises is the effectiveness of helping students connect knowledge with the technical skills learned at school. In previous discussions, it was stated that an inherent concern in school is the inability of these students to connect existing knowledge with the skills learned (Kilbrink & Bjurulf, 2012; Lappalainen et al., 2012; Lou et al., 2010). It is thus apparent that the approach to the classroom method needs to be improved with the introduction of reflective learning concepts. In general, the reflective learning approach introduced by Dewey (1933) emphasized the importance of the ability to integrate information from multiple sources and problem-solving. Doyle (1992) adds that this concept of learning can help students not only connect knowledge and skills, but also help students become more critical when analyzing, interpreting and applying new and existing knowledge in performing a task. Also, Wallace (1991) has outlined the importance of reflective thinking in the development of professional competence in learning. He emphasized that new and existing knowledge needed to undergo a reflective process to produce a clearer, more accurate and practical knowledge of individual professional development. In short, these elements of learning need to be emphasized not only to address the problems of knowledge and skills, but also to assist in understanding the concepts and content of learning to ensure that student achievement is at a proud level.

In light of the issues with the current school delivery method, it is important to change the pedagogy of learning in this institution by introducing the flipped classroom method with an emphasis on reflective learning concepts. The justification for this module was developed to provide comprehensive guidelines on how to implement the curriculum at a micro level (Batista et al., 2010). The findings of this study will create opportunities for teachers and students in schools to use reflective classroom learning strategies as a backdrop and to adapt to real learning contexts. Additionally, this study will benefit the school curriculum makers and all education institutions in the Ministry of Education Malaysia. Graduates generated through the education system will be better equipped to meet the needs of the market and contribute to a globally competitive workforce.

1.3 Purpose of the Study

The primary purpose of this study is to design and develop Motion Virtual Laboratory (MoViL) Modulein in the topic of speed and acceleration for form two students. The Motion Virtual Laboratory (MoViL) Module would help to improve students' understanding on the concepts and ideas on speed and acceleration. Using learning module also gives the students the opportunity to control the learning process by allowing the students to access the module both during class time and outside the class.

The purpose of this study is to develop a flipped classroom MoViL module based on reflective learning to help students connect their knowledge and skills during the teaching of the Speed and Acceleration topic at school. During the module development process, the researcher studied the needs of students and teachers to produce an effective MoViL module that covers both the technology aspects and teaching strategies required to teach the subject effectively. Given the characteristics of knowledge and teaching methodologies in line with current technological advances, the development of the MoViL module is appropriate and valuable for consideration. The module was created with the help of expert opinions and group decisions on which learning activities should be included in the module and how the activities should be structured within the module.

1.4 Research Objectives

The study on module design and development focused on the product development process, which consisted of three phases, each of which used a distinct methodology for data collection purposes (Saedah et al., 2013). Therefore, data collection for this project was done in stages. The objectives of the study were also developed based on the three main phases of the study, including (1) the needs analysis phase, (2) the design and development phase, and (3) the implementation and evaluation phase, to gather data that could provide an efficient module. The objectives of each phase are described as follows:

Phase 1: Needs Analysis

1. To identify the needs of the development of the Motion Virtual Laboratory (MoViL) module based on teacher's view and students' views.

Phase 2: Design and Development

2. To design and develop the Motion Virtual Laboratory (MoViL) module in the topic of speed and acceleration for form two students.

Phase 3: Implementation and Evaluation

3. (a) To determine whether there is significant mean difference in pre achievement test in speed and acceleration between form two students who learned through Motion Virtual Laboratory (MoViL) Module and conventional method.

   (b) To determine whether there is significant mean difference in post achievement test in speed and acceleration between form two students who learned through Motion Virtual Laboratory (MoViL) Module and conventional method.

(c) To determine whether there is significant mean difference in retention of achievement test in speed and acceleration between form two students who learned through Motion Virtual Laboratory (MoViL) Module and conventional method.

1.5 Research Questions

Based on the research objectives of the study, the following research questions for the study were formulated according to the three phases:

Phase 1: Needs Analysis

1.1 What are the components needed to develop MoViL module for teaching the concept of speed and acceleration among Form Two Mathematics students?

1.2 What are the students' need to develop the MoViL Module?

Phase 2: Design and Development

2. How to design and develop the Motion Virtual Laboratory (MoViL) module for form 2 students?

   a. What are the learning outcomes of the Motion Virtual Laboratory (MoViL) module?

   b. What are the content of the Motion Virtual Laboratory (MoViL) module?

c. What are the appropriate learning strategies in the Motion Virtual Laboratory (MoViL) module?

d. What are the appropriate assessment method in the Motion Virtual Laboratory (MoViL) module?

Phase 3: Implementation and Evaluation

a. Is there significant mean difference in pre achievement test in speed and acceleration between form two students who learned through Motion Virtual Laboratory (MoViL) Module and conventional method?

b. Is there significant mean difference in post achievement test in speed and acceleration between form two students who learned through Motion Virtual Laboratory (MoViL) Module and conventional method?

c. Is there significant mean difference in retention of achievement test in speed and acceleration between form two students who learned through Motion Virtual Laboratory (MoViL) Module and conventional method?

1.6 Research Hypotheses

The study is guided by the following hypotheses formulated at 0.05 significance level. There is no hypothesis tested to answer research questions in phase 1 and 2. In an attempt to answer the research questions in phase 3, the following hypotheses are tested in the study: