Information Technology Capability (ITC) Framework to Improve Learning Experience and Academic Achievement of Mathematics in Malaysia

Lew Sook Ling and Sivapoorani Krishnasamy
Faculty of Information Science and Technology, Multimedia University, Malaysia
sllew@mmu.edu.my

Abstract: Poor mathematics performance was generally reported from international assessments such as Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) among Malaysian students. Malaysia is ranked 52nd and 48th in the assessments for 2012 and 2018 respectively, while Singapore, Japan, South Korea, and even Vietnam have consistently performed well and held the top spots among the 78 countries evaluated in the PISA. Although numerous new technologies have been introduced, developed and implemented for education, incorporation of IT capability (ITC) to teach and learn Mathematics where still lacking commonly. Additionally, learning Mathematics in the traditional teaching contents could not accomplish desired learning outcomes because of dry contents and dull teachers. Therefore, this study is to design an appropriate ITC framework for improving learning experience and academic achievement of learning Mathematics. This study has adopted the development model of Analysis, Design, Development, Implementation and Evaluation (ADDIE) and Mayer (2010)'s cognitive theory for multimedia instructional content design. This study developed a new Multimedia Probability and Statistics system (MMPASS) for a subject of Probability and Statistics. The developed topics were concepts of discrete random variables and probability distribution function which were puzzled by students from preliminary study. An experiment was conducted with both control and experimental groups. The developed MMPASS blended multiple influential multimedia elements in the learning contents. A quantitative method and proportional stratified sampling were used to collect data. The blended topics were used by the experimental group whilst the control group was solely learning using the existing learning contents. Questionnaires were distributed to both groups after the lessons. 66 students participated in this survey. The collected data was then analysed and an ITC model was formed. Results of this study show that Perceived System Quality, Perceived Information Content Quality and Perceived System Performance as independent variables significantly improved learning experience. The findings also reveal that the performances of the experimental group have a higher mean score (9.65/10.00) compared to the control group (8.03/10.00), indicating the use of MMPASS improved students' learning performance in subjects that involve understanding of concepts. While there is a lack of established ITC framework and IT application for Mathematics education in Malaysia, this study has verified the use of ITC improving performance of learning Mathematics in Malaysia.

Keywords: IT capability, Students' interest, Learning experience, Multimedia learning context, Academic achievement of mathematics

1. Introduction

The important role of Mathematics grows in all areas such as Analytical, Science, Engineering, Finance Medicine and Computing Science. Basic arithmetic and estimation are very important in education, even in our daily life. For example, using algebra to study the symmetry in chemistry and calculus for molecular structure. Furthermore, Mathematics also provide ability to interpret (logical reasoning), analyse information, simplify and solve problem (Tan, 2012; Nagasaki, 2017; Adelabu, Makgato and Ramaligela, 2019). The most recent results of the Programme for International Student Assessment (PISA) 2018 revealed that Malaysian teenagers continue falling behind their regional and global peers (Table 1). Despite a slight improvement in PISA 2018 compared to PISA 2012, Malaysia remained in the lower segment of the rankings (Borzsonyi, n.d.; Kean Hin, 2020; Mahdzir, 2016) This problem should be a concern and increase the performance of the students in Mathematics across the nation.

Table 1: PISA mathematics scale by jurisdiction for 2015 and 2018

Year	2012		2015		2018	
Jurisdiction	Rank	Average Score	Rank	Average Score	Rank	Average Score
Singapore	2	573	1	564	2	569
Japan	7	536	5	532	6	527
South Korea	5	554	7	524	7	526
Vietnam	17	511	22	495	*	*
Malaysia	52	421	*	446	48	440

Note: *No data available. Source: https://pisadataexplorer.oecd.org/ide/idepisa/dataset.aspx

Reference this paper: Lew, S.,L., and Krishnasamy, S., 2023 Information Technology Capability (ITC) Framework to Improve Learning Experience and Academic Achievement of Mathematics in Malaysia, *The Electronic Journal of e-Learning, 21(1)*, pp 36-51, available online at www.ejel.org

Students' interest is one of the core factors for better learning experience as well as higher academic achievement. However, students have no interest to learn Mathematics subject and their participation are low because of uninteresting learning method (Siti, 2013; Yeh, et al., 2019). When mathematics concepts are not connected to real-world issues and are just seen as numbers, mathematics becomes boring (Chand S, 2021). Learning Mathematics needs to involve students' participation for understanding the boring concepts. Thus, the concepts of Mathematics should be related to real-life problems and presented in an interesting way. It is important to choose an appropriate information technology capability (ITC) in learning Mathematics which can promote students' interest effectively. This is due to the fact that, despite several new technologies being invented, introduced, and applied in the field of education, the inclusion of IT capability (ITC) to teach and study mathematics was still commonly lacking.

Multimedia learning is one of the effective learning approaches that was explored through ITC. In learning Mathematics, multimedia is very useful and productive because of its characteristics of interactivity, flexibility and incorporation of various media elements that can support and boost students' motivation, interest and confidence level (Pulasthi and Sellapan, 2016; Luiza, 2017; Ben, 2018).

Interactivity in multimedia content learning allows control over the lessons. Learners can change parameters, perceive their results or respond to a choice selection. Students regularly try to solve mathematical problems by substituting parameters to a standard formula/equation without reaching an understanding of the actual meaning. As stated in Mayer (2010)'s cognitive theory of multimedia learning, "it is essential to integrate both picture and definition methods to improve students' existing knowledge to enlarge it with the new facts". Hence, multimedia can visualise better mathematical ideas, formulas, theoretical names and issues (Dena, 2014; Sri, Kalaiarasi and Lew, 2018; Ben, 2018).

New technology has improved the effectiveness and efficiency of learning Mathematics (Lai D., 2021; Lai D., 2022). In this study, a learning framework was developed with integration of multimedia for Mathematics. A variety of multimedia elements were included in the developed ITC framework for learning mathematics. Three independent variables (IVs); (1) Perceived System Quality (IV1), (2) Perceived Information Content Quality (IV2) and (3) Perceived System Performance (IV3) and two dependent variables (DVs); (1) Academic Achievement (DV1) and (2) Learning Experience (DV2) were used to measure the ITC system's effectiveness. Students' performances were used to evaluate the framework's effectiveness. The results showed positive impacts in learning Mathematics.

The developed framework is aimed to improve the mathematics performance for Malaysia students. This aim is in line with the aspiration of Malaysia Education Blueprint 2013-2025, particularly the Education National Key Results Areas (NKRA) which is to improve the student outcomes in Malaysia's school system and to enable access to quality education for all students (Malaysia, n.d.). Students can learn Mathematics effectively with the developed IT application that incorporated the IT capabilities. While Mathematics being a fundamental knowledge for all disciplines, improving student outcomes in Mathematics could develop a more competitive workforce as Malaysia pushes towards becoming a high income and advanced nation by 2025 under the Twelve Malaysia Plan 2021-2025 (Yaakob, 2021; Zainuddin, 2021).

1.1 Problem Statement

In PISA 2015, Malaysia scored 446 marks in Mathematics and marked improvement over previous PISA (421 marks). Unfortunately, Malaysia was not featured in the 2015 PISA rankings although 9,660 students from 230 schools in Malaysia took part (Mahdzir, 2016). There were only 51% response rate from Malaysian schools, far below the benchmark response rate of 85% from other countries. Thus, the results were not valid for this low response rate. In PISA 2018, Malaysia scored 440 marks in Mathematics, despite a minor improvement over PISA 2012, Malaysia remained in the lowest mark category (below 450 marks) of the rankings in PISA 2018 (Borzsonyi, n.d.; Kean Hin, 2020; Mahdzir, 2016). In TIMSS 2015, Malaysia scored 465 marks where 25 marks more than the from previous TIMSS (2011) score. Even though the score improved, it is still "below average" than the global average score of TIMSS which is 500. Generally, the major issues in poor academic achievement of mathematics are students' lack of interest and confidence level to solve a mathematics problem (Filiz, 2013; Yeo, Tan and Lew, 2015; Sri, Kalaiarasi and Lew, 2018; Mohammad, Fitra and Hamsyah, 2018). Uninteresting learning method will cause low students' interest and participation (Siti, 2013). Besides, students have difficulties to understand the concepts of mathematics. Tan (2012) said that learning mathematics needs to involve students' understanding. Thus, the concepts of mathematics should be related to real life problems and presented in interesting way. Therefore, the lack of interest and confidence level cause poor learning experiences among the students. Furthermore, due to a lack of understanding of mathematics concepts, which is reflected in poor performance, Malaysia's workforce will be less competitive, limiting its ability to contribute to the country's goal of being a high-income, advanced nation by 2025. In contrast, good learning experiences contributes for better academic performance (Kelly, et al., 2010; Clark and Mayer, 2016). Previous studies (Khalid, 2009; Cemil, et al., 2010) showed the integration of IT in learning is quite low, although IT has been contributing positive impacts in Mathematics (Babettte and Tim, 2011; Filiz, 2013; Yeo, Tan and Lew, 2015; Sharon, 2017).

1.2 Significance of Research

This study was proposed from the poor Mathematics performance among Malaysian students in several programmes such as foundation, PISA and TIMSS. The developed framework is aimed to improve the mathematics performance for Malaysia students. Students can learn Mathematics effectively with the developed IT application that incorporated the IT capabilities. While Mathematics being a fundamental knowledge for all disciplines, improving student outcomes in Mathematics could develop better personnel to develop the country.

Furthermore, the developed framework is useful for Probability and Statistics subject, students, lecturers, researchers and system developers of Probability and Statistics. All the empirical insights in this study are useful for the theoretical development and future researchers.

1.3 Objective of Research

The overall aim of this research is to improve learning Mathematics by integrating an information technology capability (ITC) framework. The specific objectives are as follows:

- To design an appropriate ITC framework for learning Mathematics.
- To evaluate the relationship between ITC, learning experience and academic achievement of learning Mathematics.

2. Literature Review

The characteristics learning experience, multimedia learning and the adopted model to design and develop an effective ITC framework in this study are discussed.

2.1 Learning Experience With Technology

Vinesh and Jo (2012) and Yeo, Tan, and Lew (2015) found that technology can build learners' confidence level by reducing their anxiety. Technology can also help learners to grasp language more quickly by motivating them. Teaching and learning using e-audio and e-visual (e-AV) were tested improving learning experience (Siti, 2013). A total of 256 students from a high school in Indonesia participated in a quasi-experiment with two different teaching methods: one with entirely media instruction through e-AV Biology and the other with teaching method. After using e-AV Biology, the performance of the instructional media was evaluated. The mean scores of Biology were improved from 14.60 to 20.35. In terms of students' interest, the interest had improved significantly with mean scores from 3.84 and 4.06.

Users can learn through the interaction. Interaction is the process of engaging the experience for learners to achieve their personal goals (Patrick A. Müller, 2020; Dario Cottafava, 2019). The ability to solve new problems by applying the newly learned materials in reality is an example of interest or engaging process. This ability can be measured by a retention test. Interest or engagement process can be assessed by retention test (Kristian, 2006; Dick and Hollebrands, 2011; Mohammad, Fitra and Hamsyah, 2018). Interaction, course, program or any other experiences that an individual has in the process of learning is considered as learning experience. Furthermore, achievement of academic, users' perception of motivation, interest and confidence measure users' learning experience (Ertmer and Ottenbreit, 2010; Dena, 2014; Tan, 2012; Sri, Kalaiarasi and Lew, 2018). With this notation, in this study, learning experience is measured by academic achievement, interest, confidence level and users' perception of the system.

2.2 Multimedia Learning Context

Multimedia learning context comprises multimedia elements such as text, image, video, audio and animation which support learning experiences and showed positive impacts in learning (Paturusi, Yoshifumi and Usagawa, 2012; Haftamu, 2016; Ben, 2018; Mohammad, Fitra and Hamsyah, 2018; Reza, Zulela and Mohamad, 2019). One of the main capabilities is allowing students to visualise and manipulate the contents of learning in a different perspective such as animation based on analogy examples for Mathematics (Sharon, 2017). Students can learn by seeing, hearing, visualising and manipulating content using multimedia elements used in the animation. In addition, multimedia elements are influencing learners' attitudes towards learning. Thus, the developed ITC framework is an integration of impactful multimedia elements supporting educational principles.

According to cognitive theory, the more learning resources to be used, the less percentage of brain will be involved in retaining the memory (Mayer, 2010). The process of information in working memory can be reduced by using effective multimedia elements (Abbas, 2012; Li, Neo and Neo, 2013). This is due to the content delivery by auditory channel and visual channel in working memory is reduced. The processing of information can be heard through auditory channel and seen through visual channel. Mayer (2010) claimed that in multimedia learning, the process of information in our brain is more effective. Hence, the learning can be effectively achieved throughout the engagement of learners in cognitive processes of information in our brain by using effective multimedia elements.

The cognitive theory of multimedia learning was investigated by many researchers (Abbas, 2012; Jenny, 2014; Vinesh and Jo, 2012; Filiz, 2013). These studies presented the principles that learning process is more effective by minimising the processing load on the working memory (Abbas, 2012; Filiz, 2013). Meysun and Thair (2016) conducted a study using cognitive theory of multimedia learning. The study showed an improvement in the students' achievement. This study proved that when the multimedia elements were employed properly into the educational process can improve students' understandings and help students to achieve higher academic scores. Li, Neo and Neo (2013)'s study showed students learn better by choosing the cognitive theory of Mayer (2010)'s cognitive theory to design the learning goals. This study supported multimedia learning can raise up level of interest, retention rate and academic achievement of students. However, their study was to acquire students' perception towards a student-centred learning environment only which was not focusing on ICT that will be discovered by this study. As a result, in this study, the engagement of learners using cognitive theory via impactful multimedia learning is proposed for higher academic achievement.

2.3 Multimedia Learning Context Design and Development

Figure 1 shows the most popular model used for instructional design is the analysis, design, development, implementation and evaluation (ADDIE) model (Aldoobie, 2015; Branch, 2010). This model helps the instructional designer to create effective and efficient instructional design. ADDIE model is identified as an effective model to design a good instructional learning. The model name, ADDIE was formed by the first character of its five phases "(1) analysis, (2) design, (3) development, (4) implementation and (5) evaluation". The first phase of ADDIE model explains the instructional issues, objectives, identify learning environment and learners' existing skills and knowledge. The second phase contracts with learning objectives, media selection, assessment, instrument and content. The third phase is for developers or instructional designer design the story boards with integrate technologies. The fourth phase emphases on developing procedures. The final phase of ADDIE model ensures all the objectives are achieved throughout the learning process.

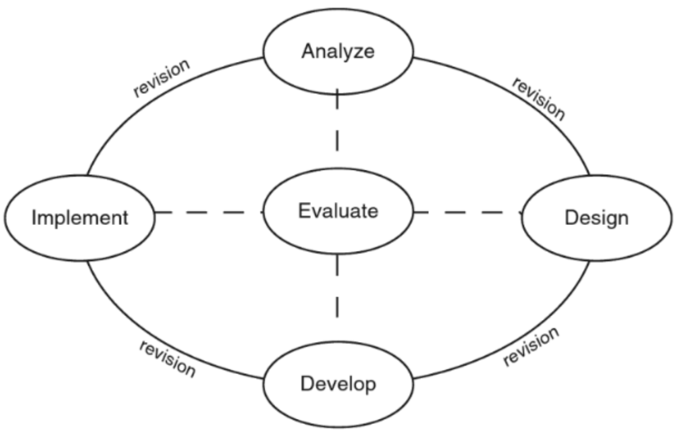

Figure 1: The ADDIE concepts

The effects of ADDIE instructional design using multimedia improving learning skills was evaluated by Azimi, Ahmadigol, and Rastegarour (2015). As a result of the study, the students who were trained using multimedia, scored higher mean scores as compared to students who were trained with traditional method. Therefore, ADDIE model was found effective for instructional design. In addition, Mohammad, Fitria and Hamsyah (2018) conducted a study of improving mathematical reasoning by integrating interactive multimedia in mathematical problem solving. The model used in the study were developed using ADDIE instructional design. The findings supported that students gained better problem solving skills and have a significant impact on their mathematical reasoning. As a conclusion, the literature review studies proved that the ADDIE model has a positive impact in the multimedia learning process. Therefore, ADDIE model has been adopted in the framework of this study.

2.4 Media Elements in Multimedia Instructional Content

The attitudes and behaviours of learners towards multimedia content learning are substantially influenced by the types of media elements. Table 2 shows various media elements that were commonly aided multimedia learning (Xiaohui and Mark, 2010; Siti, 2013; Nuraini, 2016).

Table 2: Various media elements and its purposes for multimedia learning

Media Elements	Purposes
Animation, simulation, video	Virtually explain, Animated PA
Button, help, image, link, search	Navigation
Diagram, process model or flowchart	Examples, representations
Chart, concept map, graph	Demonstration, relationship
Text	Explanation and narration

In this study, text, images, audio and animations were used to present the learning content. For instance, mixture of analogy, animation and formulas were used to elaborate the steps of processes.

2.4.1 Animated Pedagogical Agent

Animated pedagogical agent (PA) refers to an agent used to assist students in multimedia content learning (Yeo, Tan and Lew, 2015). Animated PA creates new learning experience that will stimulate students' engagement and interest in students' learning. Animated PA interacts and transmits information to students by either verbal or nonverbal behaviour (Kristijn, Ivaan and Dejan, 2012; Yeo, Tan and Lew, 2015). Kristijn, Ivaan and Dejan (2012) found that animated PA also increases confidence level of students and encourage them to put in more effort in order to succeed in their academic performance. In the current study, animated PA is integrated to deliver the learning content. The animated PA is developed using Adobe Photoshop and Adobe Animate CC. Action script 3.0 is used to code the program.

2.5 Guidelines and Protocols for Multimedia Instructional Content

The developers must define the presentation of learning contents based on multimedia cognitive theory. Design guidelines derived from the cognitive theory of multimedia learning could be used to engage cognitive processing and teaching approaches in mathematics education to enhance learning (Chiu and Churchill, 2015). Multimedia learning would provide for even more in-depth cognitive processing than standard text-based articles, resulting in improved knowledge, sharing, adoption, reputation, and relevance (Mirkovski, Gaskin, Hull and Lowry, 2019). There are three important cognitive processing capacity aspects that are able to achieve the learning objectives and which are extraneous processing, essential processing, and generative processing (Clark and Mayer, 2016). The objectives of multimedia learning are related to the three stages of cognitive processing in terms of essential, extraneous and generative. Table 3 presents the cognitive processing mapping to multimedia principles by Clark and Mayer (2016).

Table 3: Cognitive processing and multimedia principles

Cognitive Processing	Multimedia Principles
Managing Essential Processing	Modality, Pre-Training, Segmenting
Demoting Extraneous Processing	Coherence, Contiguity, Redundancy, Signalling, Spatial Contiguity, Temporal
Promoting Generative Processing	Image, Multimedia, Personalisation, Voice

Clark and Mayer (2016) suggested two keys to create a meaningful context in learning. The first key is to understand the audience or learners. The developers should take effort to understand the perspective of learners, prior knowledge and experience. Furthermore, exploring knowledge on the contents and interest are also very important. Secondly, listening to the audience during early stages of system design such as reviews. The last key is to adapt the audience into the development of framework. If the learners' experience come with identical prior experience means the developers work is straightforward. The developers need to connect to the audience even if the path given is not prescribed by the subject expert.

Designing an effective multimedia instructional content-based application, there are some basic principles should be considered (Kuba, et al., 2021; Mayer, 2017). Table 4 presents 8 basics principles by Clark and Mayer (2016).

Table 4: Multimedia principles

Multimedia Principles	Definitions
Multimedia Principles	Learners learn through words and graphics than words. Multimedia principles help to integrate words and graphics effectively.
Contiguity principle	Contiguity principle is the words to be aligned simultaneously to corresponding image.
Modality principle	Modality principle is to exhibit text in audio versus visual text on screen.
Redundancy principle	Redundancy principle is to explain the visuals with narrated audio or text on screen but not simultaneously.
Personalisation principle	Personalisation principle is emphasised on the use of a familiar way of expression such as the use of pedagogical agent.
Worked Examples	Solving problem by showing solution gradually and carefully from one stage to the next.
Practice	Unsolved exercises are designed to train learners to solve the rest of the task by reading the worked examples. By following the steps from worked examples, learners are able to solve the problem by themself.

Previous studies suggested few criteria to present the multimedia learning contents because learners must be attracted to the learning contents (Tsung, 2010; Vinesh and Jo, 2012; Leow and Neo, 2014; Obizoba, 2015; Meysun and Thair, 2016; Nuraini, 2016). Besides, unnecessary multimedia elements in instructional materials will distract the learners' interest.

Meysun and Thair (2016) conducted a study using cognitive theory of multimedia learning. The study shows an improvement in the students' achievement. Hence, the multimedia elements were employed properly into the educational process and improved students' understandings and helps students to achieve higher scores. Meysun and Thair (2016) presented guidelines to present texts, images, audios and video or animation based on principles of multimedia learning.

Nuraini (2016) discussed multimedia learning contents in individualised learning environment manner. The findings of this study showed that the learning contents were well-presented using multimedia learning contents based on the user acceptance test. The user acceptance measure module of contents, multimedia elements, navigations and usefulness.

The colour of background and text increase the readability of users and also boost their learning retention (Jiménez, et al., 2020; Mayer, 2017). The colour selection for developed framework used based on the colour codings. Table 5 shows the choice of colours and its characteristics proposed by Rick, Tara and Donna (2014).

Table 5: Choice of colours and characteristics

Colour Choice	Characteristics
Red	Red helps learner to remember the important points. Melissa (2015) suggested to write the key points in red colour.
Green	Green is a relaxing colour which can improve student concentration.
Blue	Blue provides a peaceful feeling, creativity and also improve learners' reading comprehension.
Yellow	Yellow can be used to highlight of contents. The learners are able to pay more attention using yellow. Melissa (2015) suggested to use this colour to highlight the contents and use it as borders on hand-outs.
Orange	Orange boosts learner's mood to feel comfortable and it improves the functions of brain.
Overlay Orange	Overlaying orange in white background can be used for autism students (Melissa, 2015).

The protocols and guidelines in Tables 2, 3, 4 and 5 were adopted in this study to improve multimedia instructional contents that found by Meysun and Thair (2016), Nuraini (2016), Clark and Mayer (2016) and Rick, Tara and Donna (2014). These protocols and guidelines are used during the process of framework development because it's successfully implemented and improved students' learning experience and performance of Mathematics in past studies. Therefore, the current study adopted Mayer (2010)'s cognitive theory, ADDIE model and keys to design a meaningful multimedia instructional content by Meysun and Thair (2016), Nuraini (2016), Clark and Mayer (2016) and Rick, Tara and Donna (2014).

3. Methodology

A procedural plan was used to acquire answers for research questions and objectives (Ranjit, 2011). It works on testing and makes a common description of method of certain relations. This study applied hypothesis testing on the developed framework in order to evaluate the relationships between information technology capability (ITC), learning experience and academic achievement of Mathematics. Two research questions were identified as

- What is the appropriate ITC framework for learning Mathematics?
- Are there any significant relationships between IT capability, learning experiences and academic achievement of Mathematics?

3.1 Research Procedures

Sekaran and Bougie (2016) suggested a sequential research procedure to execute the planning and designing phase. The suggested research procedures were adopted. Figure 2 represents the flow of research procedures (Sekaran and Bougie, 2016).

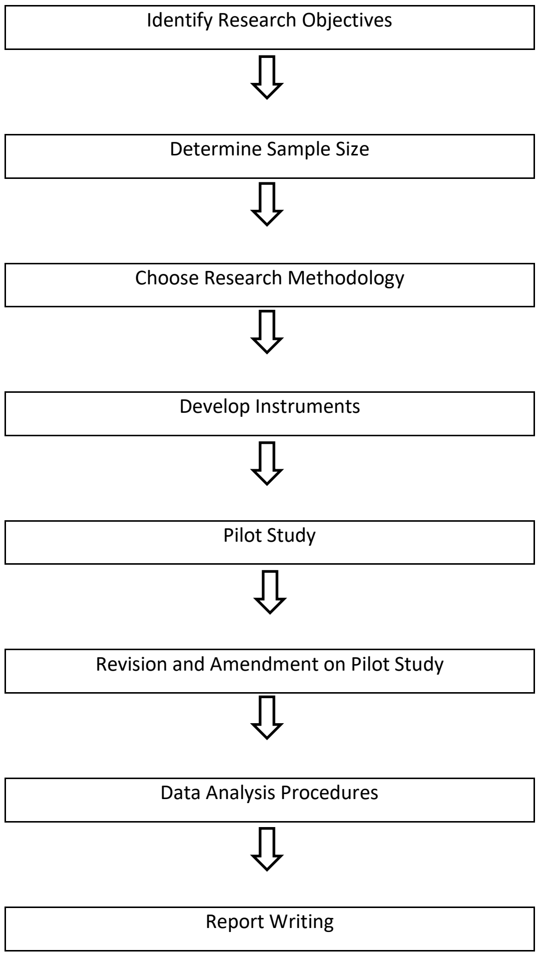

Figure 2: Flow of research procedures

3.2 Sampling Design and Demographic Analysis

Table 6 shows the summary of respondents' demographic profile. This study used Stratified sampling method to divide the students into experimental and control group. For proportional stratified sampling, gender, race and level of education can be used to split the sampling groups (Ranjit, 2011). Hence, the population was split into two groups by the students' academic achievement in overall (Cumulative Grade Points Average, CGPA) of their education level.

Table 6: Demographic profile of respondents (n = 66)

		Count	Percentage
Gender	Male	51	77.3
	Female	15	22.7
Age	Below 18	33	15.9
	18 and above	55	84.1
Most preferred Tools	Computer	58	87.9
	Scientific calculator	57	86.4
	Smartphone	56	84.8

3.3 Instrument

A questionnaire was used as an instrument. The use of questionnaire was to evaluate the students' perception towards the developed information technology capability (ITC). The questionnaire contains four main key variables namely "Learning Experience", "Perceived System Quality", "Perceived Information Content Quality" and "Perceived System Performance". All the variables use 5-point Likert scale.

3.3.1 Questionnaires design

Table 7 presents the type of questions, sources and measurement that were used in the questionnaire.

Table 7: Structure of questionnaire

Sections	Types of Questions	Sources	Measurement
Section A **General information**	Closed ended questions	Siti (2013), Jenny (2014) and Dena (2014)	Demographic information
Section B **Students' perception**	Closed ended questions using 5-point Likert-scale	Paturusi, Yoshifumi and Usagawa (2012), Siti (2013), Jenny (2014) and Dena (2014)	(1) Learning Experience (2) Perceived System Quality (3) Perceived Information Content Quality (4) Perceived System Performance
Section C - Students' suggestions and opinions	Open ended questions	Self-designed	Suggestions and opinions

3.4 Multimedia Elements of MMPASS

Table 8 shows the multimedia elements that have been integrated in Multimedia Probability and Statistics system (MMPASS) and its description (Xiaohui and Mark, 2010; Yeo, Tan and Lew, 2015; Sivapoorani, Lew and Tan, 2016; Clark and Mayer, 2016)

Table 8: Adopted multimedia elements

No	Multimedia Elements	Description
1	Text	Simple font type, colour coding (blue, green, red, and yellow).
2	Images	Pairing audio and images to illustrate practical examples.
3	Audio	Good quality audio, low speech rate and simple language.
4	Animation	Usage of animated PA and presenting complex mathematical concept by practical examples.

3.5 Examples of Animations

An animated pedagogical agent (PA) shows in Figure 3. This PA was designed and included in the developed MMPASS. The PA can be played as lecturer or tutor role. She speaks clearly, slowly and simple English. She teaches lecture contents and guides solving mathematical problems using animations, audio, text and images.

Figure 3: Animated pedagogical agent

Figure 4, Figure 5 and Figure 6 show three examples of animations by MMPASS to teach the concept of discrete and continuous random variable. Figure 4 (Example 1) illustrates and visualises discrete random variable. The animation illustrates and visualises the concept of a car parked in a parking lot in a given time by using texts, car images, car action, time narration and audio. Figure 5 (Example 2) shows discrete random variable. This figure illustrates and visualises the number of cars entering car wash by using texts, car images, car wash images, car action and audio. Figure 6 (Example 3) shows continuous random variable. This figure illustrates and visualises the time taken to complete a Mathematic test. Exam papers are used as image and arrow symbol is used to indicate the time left.

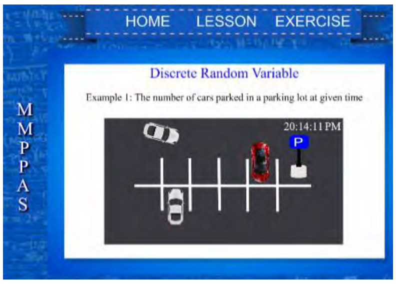

Figure 4: Discrete random variable 1

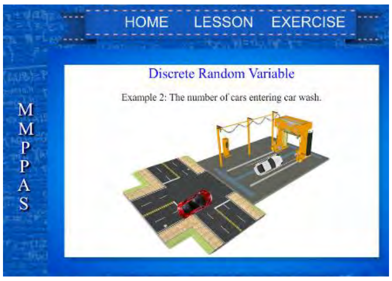

Figure 5: Discrete random variable 2

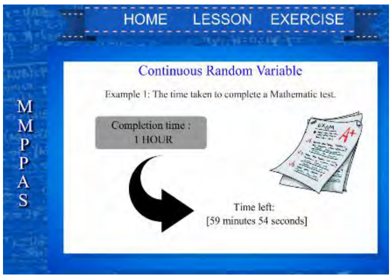

Figure 6: Continuous random variable

Figures 7, 8 and 9 are some examples of images and texts used in this study. Figure 7 illustrates and visualises the probability of coin tossing. Red colour is used to highlight the text and the coins. Figure 8 shows three types of questions to test if a student can identify a probability distribution function. The solution of each question is linked by a blue solution button. Figure 9 shows the solution for each question is linked in blue solution button. The green tick is used to indicate the audio explanation.

Figure 7: Probability of tossing coins

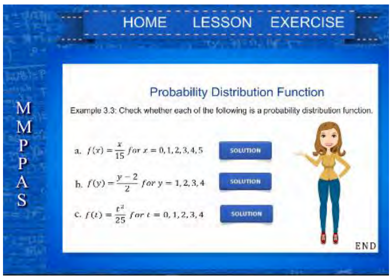

Figure 8: Example of probability distribution function

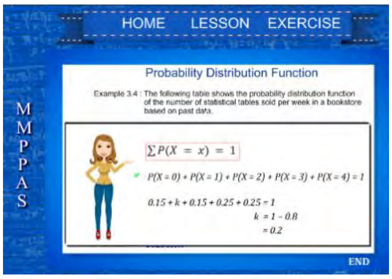

Figure 9: Solution of probability distribution function

3.6 Normality

In this study, skewness and kurtosis tests were used to test the normality of a distribution. Table 9 presents the values of skewness and kurtosis for this study.

Table 9: Skewness and kurtosis analysis

	Skewness	Kurtosis
Scores	-.897	-.460

The values of skewness and kurtosis are less than absolute value of one. Therefore, the analysed data are reasonably symmetric and considered as normal distribution.

3.7 Validity and Reliability

Validity and reliability are two important criteria in the questionnaire to ensure the developed instrument is error-free (Jenny, 2014; Sekaran and Bougie, 2016). A pilot survey was carried out on the developed questionnaire. The questionnaire was validated and reviewed by three information system and Mathematics experts. Then the questionnaire was revised based on the given comments and suggestions. These experts are senior lecturers from academic institution. Table 10 shows the values of Cronbach's alpha coefficient for the developed instrument.

Table 10: Reliability test

Items	Cronbach's Alpha
Learning Experience	0.846
Perceived System Quality	0.721
Perceived Information Content Quality	0.773
Perceived System Performance	0.708

Based on the accepted Cronbach's alpha which is greater than 0.70 this instrument is reliable (Sekaran and Bougie, 2016).

3.8 Survey

The survey was carried out with experimental and control group. The group without using ITC system is known as control and the group with ITC system is known as experimental. The control group learned the subject by a lecturer using traditional teaching method. Before the lecture commenced, a small briefing session was given to students about the ITC system and the purpose of this study. A quiz was given to both groups after the lecture session. The quiz's performances of the two groups of students were compared to verify the effectiveness of the developed ITC system. Students' perception was collected consequently using a questionnaire.

4. Results

This section initially, discusses the proposed ITC framework and followed by the overall findings of results using descriptive statistics, *t*-test and linear regression used in this study.

4.1 Data Analysis

Social Science Software Package (SPSS) analytic software was used to test the effectiveness of the information technology capability (ITC) framework and hypotheses. Independent *t*-Test and Linear regression test were used to analyse the students' performance and relationship between independent variables (IVs) and dependent variables (DVs) respectively.

4.2 ITC Framework

Figure 10 shows the developed ITC framework in this study. As shown, the ITC framework is a combination of multimedia elements in learning Mathematics. The multimedia elements were developed based on a set of multimedia instructional protocols and guidelines (Clark and Mayer, 2016; Meysun and Thair, 2016; Nuraini, 2016; Rick, Tara and Donna, 2014). The learning process is situated in the middle of the framework. The effectiveness of the ITC system was measured by three independent IVs and two DVs.

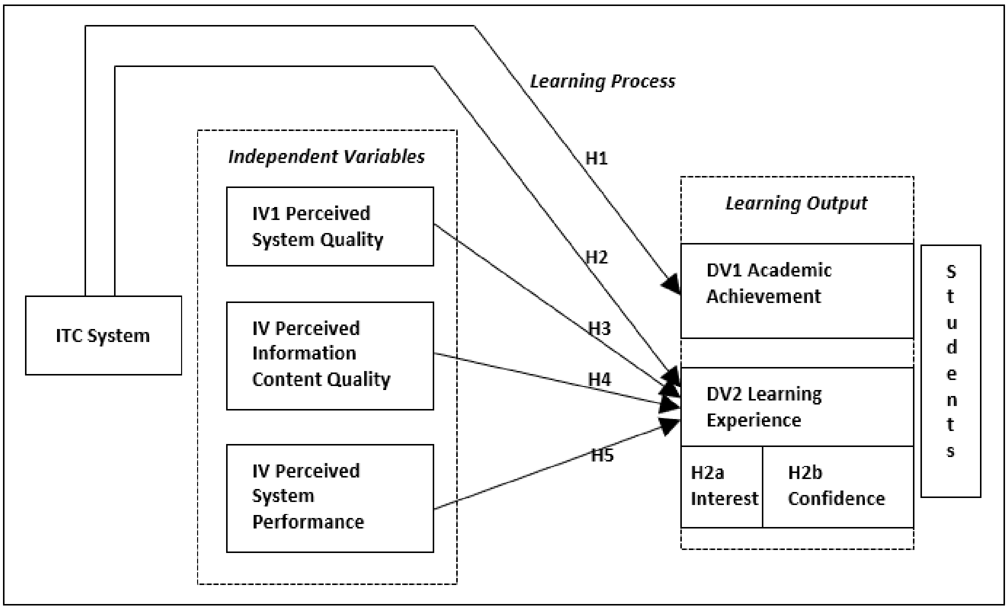

Figure 10: IT Capability (ITC) framework

Hypotheses

Hypothesis 1 (H1): "Students who use ITC system performs better in answering quiz than those who do not use the ITC system"

Hypothesis 2 (H2): "Students who use the ITC system, the better the students' learning experience"

Hypothesis 2a (H2a): "The higher the students' interest in learning, the better the students' learning experience is"

Hypothesis 2b (H2b): "The higher the students' interest in learning, the more students' confidence is"

Hypothesis 3 (H3): "The higher the perceived system quality, the better the students' learning experience is"

Hypothesis 4 (H4): "The higher the perceived information content quality is, the better the students' learning experience is"

Hypothesis 5 (H5): "The higher the perceived system performance is, the better the students' learning experience is"

4.3 Findings

Table 11 shows that the mean scores of quiz are 9.65 for experimental and 8.03 for control groups respectively. The experimental group has higher mean score compared to control group. The presented independent *t*-test result shows that there is a significant difference in mean scores between two groups as the *p*-value = 0.000 ($p<.05$). Therefore, it is proven that MMPASS is helpful in learning Probability and Statistics. Thus, the null hypothesis is rejected and H1 is accepted.

Table 11: Independent sample t-Test

	Group	n	Mean	SD	t-Test for Equality of Means		
					t	df	Sig. (2. tailed)
Scores	Control	33	8.03	1.447	5.703	64	0.000***
	Experimental	33	9.65	0.566			

***Significant at 0.05

Figure 11 and 12 presents the mean of scores in bar chart and boxplot of the mean scores of control and experimental groups respectively. The minimum and maximum values in experimental group with MMPASS are higher than the values control group. Meanwhile, the median value, lower quartiles value, upper quartiles value in experimental group with MMPASS are also higher than the values in control group.

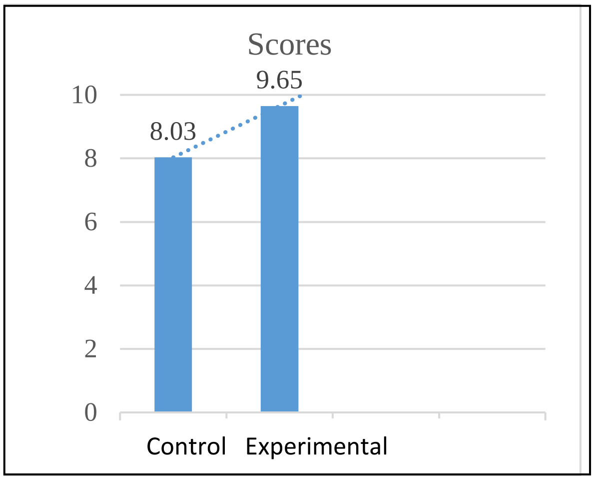

Figure 11: Scores in control and experimental groups

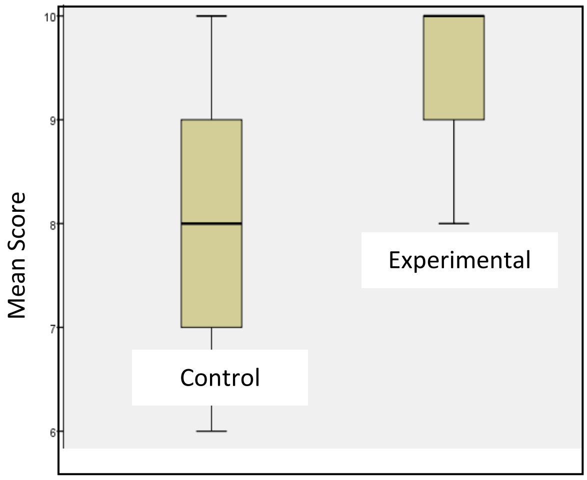

Figure 12: Box plot of mean scores in control and experimental groups

Table 12 shows a summary of hypotheses with measures of standardized beta coefficient, *p*-value and significance level.

Table 12: Summary of findings

	Hypothesis	Description
t-Test	H1	Mean scores of 9.65 and 8.03 from a total of 10 for the experimental group and the control group respectively. The mean scores are statistically significant with p-value = 0.000 (p<.05). With this, H1 is accepted.
Linear Regression	H2	
	H2a	Students' interest (p = 0.000) has a significant influence on students' learning experience by using ITC system as the p-value is found to be significant at 95% confidence interval. Based on the framework, students' interest in learning Mathematics has a significant positive influence on students' learning experience (DV2) (standardised beta coefficient = 0.839). Thus, H2a is accepted.
	H2b	Students' interest (p = 0.000) has a significant influence on confidence level by using ITC system as the p-value is found to be significant at 95% confidence interval. Based on the framework, students' interest has a significant positive influence on students' confidence level to solve a set of Mathematics questions (standardised beta coefficient = 0.693). Thus, H2b is accepted.
	H3	Perceived system quality (IV2) (p = 0.002) has a significant influence on students' learning experience as the p-value is found to be significant at 95% confidence interval. Based on the ITC framework, perceived system quality (IV2) of ITC system has a significant positive influence on students' learning experience (DV2) (standardised beta coefficient = 0.512). Thus, H3 is accepted.
	H4	Information content quality of (IV3) (p = 0.000) has a significant influence on learning experience (DV2)) as the p-value is found to be significant at 95% confidence interval. Based on the ITC framework, information content quality (IV3) of ITC has a significant positive influence on students' learning experience (DV2) (standardised beta coefficient = 0.705). Thus, H4 is accepted.
	H5	Perceived system performance (IV4) (p = 0.002) has a significant influence on students' learning experience (DV2) as the p-value is found to be significant at 95% confidence interval. Based on the ITC framework, perceived system performance (IV4) of ITC has a significant positive influence on students' learning experience (DV2) (standardised beta coefficient = 0.513). Thus, H5 is accepted.

5. Discussion

The objective of this study is aimed to improve students' learning experiences and academic achievement of Mathematics by developing an information technology capability (ITC) framework, particularly in Probability and Statistics subject. Multimedia learning is found as an effective ITC for cognitive knowledge and learning from various literatures (Sivapoorani, Lew and Tan, 2016; Sivapoorani, Lew and Tan, 2020; Saidun, et al., 2019). Therefore, an ITC application integrated with impactful multimedia elements was developed for this study ensuring its effectiveness in learning Mathematics. Three independent variables, namely "Perceived System Quality (IV1), Perceived Information Content Quality (IV2) and Perceived System Performance (IV3)" have been identified from various literatures, used in the ITC system and empirically proven to improve students' ability to learn Probability and Statistics and "Learning Experience (DV2)". This study also shows that the usage of images, text, audio and animation throughout ITC system is appropriate to enhance the learning contents to be less verbal and more effective and efficient for learning Mathematics.

Students have a better learning experience in Mathematics by having better visualisation learning content. Students feel that the contents in developed IT capability (ITC) framework were presented in an attractive way which kept their attention throughout the lessons. Based on the developed ITC framework in Figure 10, the higher the ITC, the higher the academic achievement (DV1) and the better the learning experience (DV2) in learning Probability and Statistics. Relationships between ITC, learning experiences and performance of learning Mathematics are determined as IT tools enable ITCs, ITCs contribute better learning experiences and better learning experiences which eventually improve the performance of Mathematics.

The t-test result of quiz scores proved that students from experimental group achieved the highest score than students from control group (Table 12). Students feel that the contents in MMPASS are presented in an attractive way which kept their attention throughout the lessons. Students can easily understand the contents presented in MMPASS because the contents can be visualised easily with the inclusion of animations. This result aligned with the previous studies that pointed out the changes in students' learning experiences can contribute to the improvement of academic performance (Kelly, et al., 2010; Tan, 2012; Haftamu, 2016). Specifically, learning experience of students is improved with the integration of IT. The better visualisation of contents leads students to have better learning experience.

The standardized beta coefficient for interest and learning experience scored 0.839 (Table 12). 0.839 is the highest score among all the beta coefficients. This means interest is the most important independent variable affecting the learning experience. Apart from that, results from linear regression test shows that students' interest in learning has a significant positive influence on students' learning experience by using MMPASS (Table 12). Previous studies have proven that IT can improve students' proficiency by having better learning experiences (Siti, 2013; Paturusi, Yoshifumi and Usagawa, 2012; Mohammad, Fitra and Hamsyah, 2018). Students believed that using MMPASS can increase their interest in learning. In fact, students will be more engaged and active in learning, especially in Probability and Statistics subject. Multimedia elements such as texts, images, audios and animations play a crucial role in MMPASS as it helps to attract the students' attention.

Previous studies indicated that students' interest level in learning Mathematics has influenced their confidence level (Leow and Neo, 2014; Yeo, 2015). Thus, it is consistence with this study that MMPASS has improved their confidence level when they have more interest in learning. Students are able to think about the contents of the system and relate it with the quiz questions that can help them to answer more confidently. The standardized beta coefficient for interest and confidence scored 0.693 (Table 12). 0.693 is the third highest score among all coefficients. This means confidence is ranked below information content quality and learning experience which affecting the learning experience. Apart from the results, the linear regression test on this study shows that students' interest in learning has positive significant influence on their confidence level to solve Mathematics questions (Table 12).

According to Paturusi, Yoshifumi and Usagawa (2012), system quality is concerned with systems' errors, consistency of user interface, systems' response rate, user-friendliness and quality documentation. Siti (2013) stated that information support, service, presentation and navigation play a major role in system quality concepts. Perceived system quality of MMPASS has positive effects as it has significant path towards students' leaning experience. Most of the students believed that interactive features and user-friendliness in MMPASS attracted their interest towards Multimedia learning system. The standardized beta coefficient for perceived system quality and learning experience scored 0.512 (Table 12). 0.512 is the least score among all beta coefficients. This means perceived system quality is ranked after perceived system performance and learning experience which is affecting learning experience. A linear regression test demonstrates that perceived system quality has a significant positive impact on students' learning results, in addition to the findings (Table 12).

Information content quality is concerned with accuracy, relevancy of data and timeliness created by an information system (Siti, 2013). According to Paturusi, Yoshifumi and Usagawa (2012) and Azimi, Ahmadigol, and Rastegarour (2015) the delivery of information content should consider the type of information presented, better graphics, colour codes, not distracting or annoying, and the way of information is delivered. The results indicated that information content quality had significant effects on students' learning experience. Students agreed that the provided learning materials, visual examples, objectives of lessons, contents of learning materials, colour codes and design of text used in MMPASS are well structured and appropriate. The standardized beta coefficient for information content quality and learning experience scored 0.705 (Table 12). 0.705 is the second highest score among all beta coefficients which means the information content quality is ranked after interest and learning experience affecting learning experience. The linear regression test also demonstrates that perceived system performance has a significant positive impact on students' learning experiences (Table 12).

The standardized beta coefficient for perceived system performance and learning experience scored 0.611 (Table 12). 0.611 is the fourth highest score among all beta coefficients. This means the perceived system performance is ranked after interest and confidence affecting learning experience. The linear regression test also demonstrates that perceived system performance has a significant positive impact on students' learning experiences as well (Table 12). As a result, the performance of the MMPASS system is also a significant aspect of the students' learning experience in this study.

6. Conclusion, Implications snd Recommendation for Future Research

Multimedia learning creates a better learning experience to engage students in learning Mathematics. Based on the ITC framework, a better learning experience inevitably enhance academic achievement of Mathematics. It is proven by the statistically significant mean scores in *t*-Test. The "Academic Achievement (DV1)" of the experimental group was scored higher (9.65 out of 10) than the control group (8.03 out of 10). Hence, this study concluded that multimedia learning is an effective IT capability (ITC) to improve students' learning experience and academic achievement of Mathematics.

From the theoretical aspects, the results of this study have implications for the potential use of MMPASS in education, particularly in Probability & Statistics learning material. To date, limited research has conducted to improve learning experience and academic achievement by integrating multimedia content learning in Probability and Statistics. It provides some key ideas to the existing literature in improving performance of learning Mathematics. Besides, the results of this study have contributed to the knowledge and literature in educational research. This study provides practical implications for teachers and students. MMPASS has improvised performance of teaching and learning Probability and Statistics. Thus, multimedia content learning framework could contribute a better teaching and learning experience. This study appears viable by incorporating MMPASS in Probability and Statistics classroom, specifically in discrete and continuous probability distribution topic. Therefore, there is possibility in adoption of MMPASS as tool in teaching Probability and Statistics by lecturers and learning institutes. Students are benefited through MMPASS except the control group which did not use MMPASS. In addition, performance of students in quiz significantly has improved in system class. Other than that, the findings of the study show positive perceptions towards Probability and Statistics by adoption of MMPASS as learning tool. Students' perception is measured by four aspects, namely learning experience, system quality, information content quality and system performance.

As results show positive feedback, MMPASS is considered as a good approach in improving performance of learning Mathematics, particularly in Probability & Statistic subject. However, due to time constraint, this study involved and conducted only on a small sample. In order to obtain more valuable insights on the integration of MMPASS to improve students' performance in Mathematics, a similar study can be conducted in a larger scale sample. By doing so, there are possibilities to learn more on aspects related to students' attitude, learning experiences and most importantly, performance towards using MMPASS in learning Mathematics.

Declarations

This study was funded by Multimedia University and FRGS (Ref: FRGS/2/2014/SSI09/MMU/03/2).

The article has obtained the university Public Disclosure approval.

The authors declare that they have no conflict of interest.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the university.

Informed consent was obtained from all individual participants included in the study.

References

Abbas, P., 2012. Visual, Auditory, Kinaesthetic Learning Styles and Their Impacts on English Language Teaching. *Journal of STudies in Education,* pp. 1-10.

Adelabu, M. F., Makgato, M. and Ramaligela, S., 2019. The Importance of Dynamic Geometry Computer Software on Learners' Performance in Geometry. *The Electronic Journal of e-Learning,* 17(1), pp. 52-63.

Aldoobie, N., 2015. ADDIE Model. *American International Journal of Contemporary Research,* 5(6), pp. 1-5.

Babettte, M. and Tim, R., 2011. *Integrating Technology with Student-Centered Learning,* s.l.: Nellie Mae Education Foundation.

Ben, M., 2018. Animation Production Teaching Model based on Design-Oriented Learning. *International Journal of Emerging Technologies in Learning,* Vol.13(8), pp. 172-184.

Borzsonyi, A., n.d. *PISA 2018 Worldwide Ranking – average score of mathematics, science and reading.* [Online] Available at: https://factsmaps.com/pisa-2018-worldwide-ranking-average-score-of-mathematics-science-reading/ [Accessed 22 12 2021].

Branch, R. M., 2010. *International Design: The ADDIE Approach.* 1st ed. Boston, MA : Springer Science, Business Media, LLC.

Cemil, Y., Ismail, A., Bulent, T. and Tugba, M., 2010. A Model to Explore Turkish Teachers ICT Integration Stages. *The Turkish Online Journal of Educational Technology,* pp. 1-9.

Chand S, C. K. P. A. a. C. V., 2021. Perceived Causes of Students' Poor Performance in Mathematics: A Case Study at Ba and Tavua Secondary Schools. *Front. Appl. Math. Stat.,* 7(614408).

Chiu, T. K. and Churchill, D., 2015. Exploring the characteristics of an optimal design of digital materials for concept learning in mathematics: Multimedia learning and variation theory. *Computers & Education,* 82(2015), pp. 280-291.

Clark, R. C. and Mayer, E., 2016. *E-learning and the Science of Instruction: Proven guidelines for consumers and designers of multimedia learning..* 4th ed. s.l.:s.n.

Dario Cottafava, G. C. L. C., 2019. Education of sustainable development goals through students' active engagement : A transformative learning experience. *Sustainability Accounting, Management and Policy Journal,* 10(3), pp. 521-544.

Dena, E., 2014. *Technology in higher education Mathematics: A mixed methods study ,* s.l.: s.n.

Dick, T. and Hollebrands, K., 2011. *Introduction to focus in high school mathematics: Technology to support reasoning and sense making.* s.l.:National Council of Teachers of Mathematics.

Ertmer, P. and Ottenbreit, L., 2010. Teacher Technology Change: How Knowledge, Confidence, Beliefs, and Culture Intersect. pp. 1-30.

Filiz, V., 2013. Elementary School Teachers and Teaching with Technology. *Turkish Online Journal of Educational Technology,* Volume 12, pp. 1-16.

Haftamu, M., 2016. Impact of multimedia in teaching Mathematics. *International Journal of Mathematics Trends and Technology (IJMTT),* pp. 1-5.

Jenny, R., 2014. Designing and Using Research Questionnaires. *Management Research Review,* 37(3), pp. 308-330.

Jiménez, R. et al., 2020. Short-term effects of text-background color combinations on the dynamics of the accommodative response. *Vision Research,* 166(2020), pp. 33-42.

Kean Hin, K., 2020. PISA 2018 and Malaysia. *International Journal of Advanced Research in Education and Society,* September, 2(3), pp. 12-18.

Kelly, S., Daniel, S., Catherine, M. and Fanny, C., 2010. Evaluating the Implementation Fidelity of Technology Immersin and its Reltonship with Student Achievement. *The Journal of Technology, Learning and Assestment,* p. 69.

Khalid, A. B., 2009. Barriers to the Successful Integration of ICT in Teaching and Learning Environments: A Review of the Literature. *Eurasia Journal of Mathematics, Science and Technology,* pp. 1-11.

Kristian, K., 2006. Towards a Participatory Multimedia Learning Model. *Education and Information Technologies,* 11(1), pp. 21-32.

Kuba, R. et al., 2021. Using the first principles of instruction and multimedia learning principles to design and develop in-game learning support videos. *Educational Technology Research and Development,* 69(2021), pp. 1201-1220 .

Lai D., L. S. O. S., 2022. Modified TPACK Framework for Teachers' Efficiency, Students' Performance and Students' Engagement. In: S. S. D. N. J. A. Yang XS., ed. *Proceedings of Sixth International Congress on Information and Communication Technology.* Singapore: Springer, pp. 827-835.

Lai D., L. S. O. S. Y., 2021. A Pedagogical Framework with Integration of TPACK for Mobile Interactive System in Teaching MathematicsComputational Science and Technology. In: I. H. H. H. A. P. Alfred R., ed. *Computational Science and Technology.* Singapore: Springer, pp. 27-40.

Leow, T. F. and Neo, M., 2014. Interactive Multimedia Learning: Innovating Classroom Education in a Malaysian University;. *The Turkish Online Journal of Educational Technology,* pp. 1-12.

Li, W. Y., Neo, M. and Neo, T.-K., 2013. Using Mayer's Design Principles in Online Learning Modules: Implementation in a Student Centered Learning Environment. *Informatics and Creative Multimedia (ICICM),* pp. 304-309.

Luiza, d., 2017. The effect of multimedia use on the teaching and learning of social sciences at tertiary level. pp. 1-22.

Mahdzir, B., 2016. *PISA 2015- Programme For International Student Assessment,* s.l.: Kementerian Pendidikan Malaysia.

Malaysia, K. P., n.d. *Pelan Pembangunan Pendidikan 2013-2025,* Kuala Lumpur: s.n.

Mayer, R., 2010. *Multimedia Learning (2nd edition).* s.l.:New York: Cambridge University Press.

Mayer, R. E., 2017. Using multimedia for e-learning. *Journal of Computer Assisted Learning,* 33(5), pp. 403-423.

Meysun, H. and Thair, H., 2016. Designing an Effective e-Content Development Framework for the Enhancement of Learning Programming. *International Journal of Engineering and Technology (iJET),* 11(4), pp. 1-11.

Mirkovski, K., Gaskin, J. E., Hull, D. M. and Lowry, P. B., 2019. improving the comprehension and utility in disseminating information systems research: Evidence from a quasi-experiment. *Information Systems Journal,* 29(6), pp. 1153-1177.

Mohammad, F., Fitria, N. and Hamsyah, M., 2018. Interactive Multimedia Based Mathematics Problem Solving to Develop Students Reasoning. *International Journal of Engineering & Technology (iJET),* 7(2), pp. 272-276.

Nagasaki, E., 2017. *Mathematical Literacy for Living in the Highly Information and Technology Oriented in the 21st Century: Mathematics Education from the Perspective of Human Life in Society.* Hong Kong, China, s.n., pp. 1-20.

Nuraini, C., 2016. Design and development of a multimedia courseware using personalized learning environment approach for nutrition topic. *Journal of Engineering and Applied Sciences,* pp. 1-7.

Obizoba, C., 2015. Instructional Design Models—Framework for Innovative Teaching and Learning Methodologies. *International Journal of Higher Education Management (IJHEM) ,* pp. 1-12.

Patrick A. Müller, T. B. J. S. a. S. Z., 2020. Using research methods courses to teach students about sustainable development – a three-phase model for a transformative learning experience. *International Journal of Sustainability in Higher Education,* 21(3), pp. 427-439.

Paturusi, S., Yoshifumi, C. and Usagawa, T., 2012. Development and evaluation of the blended learning courses at Sam Ratulangi University Indonesia. *International Journal of e-Education, e-Business, e-Management and e-Learning,* Volume 2.

Pulasthi, D. G. and Sellapan, P., 2016. Possibility of using multimedia application for learning. *Journal on Computing,* pp. 1-7.

Ranjit, K., 2011. *Research Methodology (3rd edition).* s.l.:SAGE Publications.

Reza, R., Zulela and Mohamad, S., 2019. *Computer-based interactive multimedia: a study on the effectiveness of integrative thematic learning in elementary schools.* s.l., s.n., pp. 1-7.

Rick, R., Tara, D. and Donna, D., 2014. Color and Contrast in E-Learning Design: A Review of the Literature and Recommendations for Instructional Designers and Web Developers. *Merlot,* pp. 1-14.

Saidun, A. et al., 2019. Developing an Interactive Mathematics Multimedia Learning Based on Ispring Developing an Interactive Mathematics Multimedia Learning Based on Ispring. *Al-Jabar: Jurnal Pendidikan Matematika,* 10(1), pp. 1-16.

Sekaran, U. and Bougie, R., 2016. *Research Methods For Business - A Skill Building Approach (Sixth Edition).* s.l.:s.n.

Sharon, N., 2017. *Educational Technology.* [Online]
Available at: https://elearningindustry.com/need-know-educational-software

Siti, H., 2013. *e-VideoVisual for Teaching and Learning Biology in Indonesian Senior High Schools (Doctoral Dissertation),* s.l.: Emerald.

Sivapoorani, K., Lew, S. L. and Tan, C., 2016. Enhancing Learning Experience Using Multimedia Context Learning in Education. *American Scientific Publishers,* 23(8), pp. 1-15.

Sivapoorani, K., Lew, S. L. and Tan, C., 2020. Improving Learning Experience of Probability and Statistics using Multimedia System. *International Journal of Emerging Technologies in Learning (iJET),* 15(1), pp. 1-11.

Sri, W., Kalaiarasi, S. and Lew, S., 2018. Impacts of m-DPBL Approach towards Computer Networks Teaching and Learning Process. *International Journal of Emerging Technologies in Learning (EJEL),* Vol.13(3), pp. 207-215.

Tan, C. K., 2012. *The effect of using graphin calculators on students' performance and attitude towards probabality and learning (Doctoral Dissertation),* s.l.: SIti Hasmah Digital Library.

Tsung, J., 2010. *Educational Benefits of Multimedia Skills Training.* s.l.:s.n.

Vinesh, C. and Jo, B., 2012. ICT driven pedagogies and its impact on learning outcomes in high school. *International Journal of Pedagogies and Learning,* pp. 73-83.

Xiaohui, L. and Mark, Z., 2010. Effectiveness of Multimedia Elements in Computer Supported Instruction: Analysis of Personalization Effects, Students' Performances and Costs. *Journal of College Teaching & Learning,* pp. 1-16.

Yaakob, I. S., 2021. *Speech by the Prime Minister,* Kuala Lumpur: s.n.

Yeh, C. et al., 2019. Enhancing achievement and interest in mathematics learning through Math-Island. 14(1), pp. 1-19.

Yeo, W. L., 2015. *Reducing Anxiety Level in Mathematics Learning Using Pedagogical Agent.* Master's Thesis. Multimedia University.

Yeo, W., Tan, C. and Lew, S., 2015. Mathematics Anxiety among Male and Female Students. *Interational Journal of Psychological and Behavioral Sciences,* p. 6.

Zainuddin, A., 2021. *Malaysia's 5-Year Plan Sets Its Sights on High-Income Status by 2025,* Kuala Lumpur: The Diplomat.