MOBILE GAME-BASED LEARNING APPLICATION IN PRIMARY MATHEMATICS: EFFECTIVENESS ON PROLEM SOLVING SKILLS AND PERCEIVED MOTIVATION ACROSS TWO DIFFERENT THINKING STYLES

AZMATH BEGAM BINTI ABDUL AZIZ

MASTER OF SCIENCE (MULTIMEDIA STUDIES)

2025

MOBILE GAME-BASED LEARNING APPLICATION IN PRIMARY MATHEMATICS: EFFECTIVENESS ON PROLEM SOLVING SKILLS AND PERCEIVED MOTIVATION ACROSS TWO DIFFERENT THINKING STYLES

by

AZMATH BEGAM BINTI ABDUL AZIZ

Thesis submitted in fulfilment of the requirements for the degree of

Master of Science

Awang Had Salleh
Graduate School
of Arts And Sciences

Universiti Utara Malaysia

PERAKUAN KERJA TESIS / DISERTASI

(Certification of thesis / dissertation)

Kami, yang bertandatangan, memperakukan bahawa
(We, the undersigned, certify that)

AZMATH BEGAM ABDUL AZIZ

calon untuk Ijazah **MASTER OF SCIENCE**
(candidate for the degree of)

telah mengemukakan tesis / disertasi yang bertajuk:
(has presented his/her thesis / dissertation of the following title):

"MOBILE GAME-BASED LEARNING APPLICATION IN PRIMARY MATHEMATICS: EFFECTIVENESS ON PROBLEM-SOLVING SKILLS AND PERCEIVED MOTIVATION ACROSS TWO DIFFERENT THINKING STYLES"

seperti yang tercatat di muka surat tajuk dan kulit tesis / disertasi.
(as it appears on the title page and front cover of the thesis / dissertation).

Bahawa tesis/disertasi tersebut boleh diterima dari segi bentuk serta kandungan dan meliputi bidang ilmu dengan memuaskan, sebagaimana yang ditunjukkan oleh calon dalam ujian lisan yang diadakan pada : **09 Disember 2024.**
That the said thesis/dissertation is acceptable in form and content and displays a satisfactory knowledge of the field of study as demonstrated by the candidate through an oral examination held on: ***09 December 2024.***

Pengerusi Viva: *(Chairman for VIVA)*	**Assoc. Prof. Dr. Mohd Khairie Ahmad**	Tandatangan *(Signature)*
Pemeriksa Luar: *(External Examiner)*	**Ts. Dr. Mohamad Lutfi Dolhalit**	Tandatangan *(Signature)*
Pemeriksa Dalam: *(Internal Examiner)*	**Prof. Ts. Dr. Ariffin Abdul Mutalib**	Tandatangan *(Signature)*
Nama Penyelia/Penyelia-penyelia: *(Name of Supervisor/Supervisors)*	**Assoc. Prof. Ts. Dr. Subashini Annamalai**	Tandatangan *(Signature)*
Nama Penyelia/Penyelia-penyelia: *(Name of Supervisor/Supervisors)*	**Abd Hadi Abd Razak**	Tandatangan *(Signature)*

Tarikh:
(Date) ***09 December 2024***

Permission to Use

In presenting this thesis in fulfilment of the requirement for postgraduate degree from Universiti Utara Malaysia, I agree that the Universiti Library may make it freely available for inspection. I further agree that permission for the copying of this thesis in any manner, in whole or in part, for scholarly purpose may be granted by my supervisor(s) or, in their absence, by the Dean of Awang Had Salleh Gradate SchSchool of Arts and Sciences. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to Universiti Utara Malaysia for any scholarly use which may be made of any material from my thesis.

Requests for permission to copy or to make other use of materials in this thesis, in whole or in part, should be addressed to:

Dean of Awang Had Salleh Graduate School of Arts and Sciences
UUM College of Arts and Sciences
Universiti Utara Malaysia
06010 UUM Sintok

Abstract

The problem-solving skills among Year 4 primary students in Mathematics vary significantly, with students generally struggling and lacking motivation to comprehend mathematical concepts, which are also influenced by their different thinking styles. Thus, this study aims to design, develop, and evaluate the effectiveness of a mobile game-based learning application, named ROMAAD, in improving mathematical problem-solving skills and perceived motivation among students with two different thinking styles. A total of 314 Year 4 students from six primary schools in Malaysia were selected and assigned into two groups using a 2 × 2 factorial quasi-experimental design. Students from three schools were designated as the control group, while the students from remaining three schools were set as the experimental group. The collected data were analysed using descriptive statistics, Analysis of Variance (ANOVA), and Paired Sample t-Test. The results prove that the students in the experimental group exhibit greater improvement in problem-solving skills compared to those in the control group. It also indicates a significant improvement in students' perceived motivation through the use of the ROMAAD application. However, the interaction effects between ROMAAD and the student's thinking styles on their perceived motivation is not significant. The study found that ROMAAD significantly improves students' mathematical problem-solving skills and perceived motivation, regardless of their thinking styles. It also proposes effective strategies for designing mobile game-based learning applications that are engaging, enjoyable, and motivating. Overall, the study offers timely and practical solutions for educators to develop interactive multimedia game applications that enhance problem-solving skills and boost students' perceived motivation across two different thinking styles. The study found that digital technology tools enhance efficiency and creativity, it raise concern about preserving traditional craftmanship. The findings indicate that digital technology tools accelerate the creative the creative and manufacturing processes but may diminish the perceived value of art. This study provides essential effects for artists, educators, and students in navigating the relationship between art and technology while preserving craftsmanship and cultural heritage.

Keywords: Mobile game-based learning, Perceived motivation, Problem solving skills, Holistic thinking style, Analytics thinking style.

Abstrak

Kemahiran penyelesaian masalah dalam kalangan murid Tahun 4 sekolah rendah dalam mata pelajaran Matematik berbeza secara signifikan. Umumnya, murid menghadapi kesukaran dan kurang bermotivasi untuk memahami konsep matematik, yang turut dipengaruhi oleh gaya pemikiran mereka yang berbeza. Oleh itu, kajian ini bertujuan untuk mereka bentuk, membangun dan menilai keberkesanan aplikasi pembelajaran berasaskan permainan mudah alih yang dinamakan ROMAAD dalam meningkatkan kemahiran penyelesaian masalah Matematik dan tanggapan motivasi dalam kalangan murid yang mempunyai dua gaya pemikiran yang berbeza. Seramai 314 murid Tahun 4 dari enam buah sekolah rendah di Malaysia telah dipilih dan dibahagikan kepada dua kumpulan menggunakan reka bentuk kuasi-eksperimen faktorial 2 × 2. Murid dari tiga buah sekolah telah ditetapkan sebagai kumpulan kawalan, manakala murid dari tiga buah sekolah selebihnya telah ditetapkan. sebagai kumpulan eksperimen. Data yang dikumpul telah dianalisis menggunakan statistik deskriptif, Analisis Varians (ANOVA), dan Ujian-t Sampel Berpasangan. Hasil kajian membuktikan bahawa murid dalam kumpulan eksperimen menunjukkan peningkatan yang lebih ketara dalam kemahiran penyelesaian masalah berbanding dengan kumpulan kawalan. Ianya juga menunjukkan peningkatan yang signifikan dalam tanggapan motivasi oleh murid melalui penggunaan aplikasi ROMAAD. Namun, kesan interaksi antara ROMAAD dan gaya pemikiran murid terhadap tanggapan motivasi mereka adalah tidak signifikan. Kajian ini mendapati bahawa ROMAAD dapat meningkatkan kemahiran penyelesaian masalah Matematik dan tanggapan motivasi oleh murid secara signifikan tanpa mengira gaya pemikiran mereka. Kajian ini juga mencadangkan strategi berkesan untuk mereka bentuk aplikasi pembelajaran berasaskan permainan mudah alih yang menyeronokkan, menarik dan mampu meningkatkan motivasi. Secara keseluruhannya, kajian ini menawarkan penyelesaian yang relevan dan praktikal kepada para pendidik untuk membangunkan aplikasi permainan multimedia interaktif yang dapat memperkukuh kemahiran penyelesaian masalah serta meningkatkan tanggapan motivasi dalam kalangan murid dengan dua gaya pemikiran yang berbeza.

Kata Kunci: Pembelajaran berasaskan permainan mudah alih, Kemahiran penyelesaian masalah, Tanggapan motivasi, Gaya pemikiran holistic, Gaya pemikiran analitik

ACKNOWLEDGEMENTS

ALHAMDULILLAH

I would like to express my sincere gratitude to all those who have supported me throughout the journey of completing this thesis.

First and foremost, I am deeply thankful and hearfelt gratitude to my supervisor Associate Professor Ts.Dr.Subashini Annamalai for her guidance, encouragement, invaluable constructive feedback and generous contribution of her valuable time to enable me to complete my Master's study successfuly. I would like to express my sincere thank you to my co-supervisor En Abd Hadi Bin Abd Razak for his feedback to further improve my thesis. Their expertise and commitment to excellence have been instrumental in shaping the direction of this research.

I wish to express my gratitude to the School of Multimedia Technology & Communication and Awang Has Salleh Graduate School for offering me Master programme at University Utara Malaysia. Special recognition is due to the members of the research proposal committee, Dr. Mohd. Nizam Saad, Ts. Dr. Azliza Othman and Dr. Hammuzamer Irwan Hamzah for their thoughtful reviews and constructive comments on the early drafts significantly contributed to the successful completion of this dissertation. I am truly grateful for their valuable insights.

I would like to acknowledge the six primary school and study participants without whom this research would not have been possible. Their willingness to participate in this study by utilising the intervention and share their experiences has been invaluable.

Above all, my heartfelt thanks go to my dearest parents, mom Saligabeham who is the source of my inspiration & dad Abdul Aziz, my siblings (Mydin, Reena & Raeezul), my fiancé Amir and my beloved friends (Sooriya, Rena, Yohalaa & Ummul) for their unwavering support and assistance. Their motivation and encouragement have been my source of strength, and I am grateful for their patience and belief in my abilities.

In conclusion, I am thankful to all those who have played a part, big or small, in the completion of this thesis. Your support has been indispensable, and I am truly grateful for the collaborative spirit that has defined this journey.

Table of Content

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

Information and communication technology (ICT) has an impact on many every aspect of human life. They are crucial to business, education, the workplace, and entertainment. Additionally, the majority of individuals agree that ICT may be used to modify working circumstances, how knowledge is handled and shared, how teaching and learning are approached, how research is conducted, and how to access information communication technology. Leverage ICT to scale up quality learning across Malaysia is one of the seven changes among eleven to modify the education system, according to the Malaysian Education Blueprint 2013–2025 (Ministry of Education Malaysia, 2013).

Implementing ICT into education which is also known as educational technology has become an essential part of the education system (Tuma, 2021). Educators nowadays tend to regard educational technology as tools or equipment that assist teaching and learning, such as computers, mobile phones, and tablets as learning media. Even so, educational technology is nothing new and is not limited to the use of digital devices (Papadakis, 2018). The use of such technology also improves students' perceived motivation, skills, attitude, and interest rather than just to learn (Jeno, Adachi, Grytnes, Vandvik & Deci, 2018).

Mathematics education is a very important goal of the national education standards and curriculum in many countries (Nunes, Dorneles, Lin, & Rathgeb-Schnierer, 2016). This includes Malaysia which acknowledge and integrates Mathematics as a

core subject to be taken in examination (MOE). In Malaysia, Mathematics is being thought and learned from preschool to secondary school, later to be implemented as major, minor and elective subjects in the higher education level.

Problem-solving skills are the main fundamental point of Mathematic education (Novriani & Surya, 2017). Nizaruddin, Muhtarom, and Sugiyanti (2017) claimed that implementing game-based learning as a technology aid in Mathematics learning can help to enhance students' Mathematical problem-solving skills. In addition, there are some other factors can also influence problem-solving skills namely thinking styles. Different style people will have different techniques of solving problems. As thinking styles can affect problem-solving skills, this research also aims to measure the relationship of thinking style toward problem-solving skills and perceived motivation in mobile Game-Based learning (mGBL) application.

Therefore, this research attempt to investigate the effect of MGBL application on mathematical problem-solving skills and perceived motivation among Year 4 primary students of different thinking style.

1.2 Background of Study

In the 21st century, digital technology has become part of education. Daud, Rafizah, Jalil, and Gunawan (2015) claimed that implementing the digital technology learning tools within the learning and teaching process could form a quick and wider range of learning. The new generation is digital natives who learn via mobile and games (Mahat, Ayub, & Luan, 2012). Using such technology can encourage the younger generations to find out remotely anytime anywhere once they wish to learn (Mahat, Ayub, & Luan, 2012).

One of the technologies in learning is interactive applications like mobile games (McKenna, Arnone, Kaarst-Brown & Chauncey). Navarrete (2013) argued that educational technology-based games can draw the eye of the students, allowing them to develop their cognition and experience along with the evolution of the games. The effectiveness of game-based learning as a pedagogical tool can create a fun and engaging learning environment for students (Offenholley, 2012). According to Hou and Li (2014), an effective educational mobile game should include problem-solving techniques and learning components so that participants can have fun while learning.

Many studies have identified that game-based learning (GBL) is an effective way to students' perceived motivation and performance (Byun & Joung, 2018). Instead of learning with textbooks, educational mobile apps and games are options for the student to take extra time to develop their skills and fact fluency. Through the application of game-based learning, students will be motivated and learn in a fun way (Al-Azawi, Al-Faliti & Al-Blushi, 2016). Moreover, GBL could help to support the development of metacognitive knowledge and skill whereby it will lead to the ability of self-learning and understanding which can influence students in solving problem-solving questions by themselves (Braad, 2018). In addition, game-based learning stimulates a rise in midbrain dopamine to assist store and recalling information (Howard-Jones & Jay, 2016).

Math learning can be effective when it is integrated into the game environment (Arnab, Lim, Carvalho, Bellotti, de Freitas, Louchart, et al. 2015). Digital games, such as video games, computer games, and mobile games, have been identified by Byun and Joung (2018) as an effective teaching strategy that can raise student enthusiasm and achievement in mathematics education. Absorbing game-based learning in

mathematics can positively impact mathematics skills and attitude to perceived motivation (Tokac, Novak & Thompson, 2019). Moreover, Al-Azawi, Al-Faliti & Al-Blushi, (2016), reported that many studies reveal that game-based learning contributes to “fun” and “pleasure” in learning to improve learners’ motivation. Additionally, the use of games in the classroom has the ability to motivate students and increase their willingness to participate in ongoing, continuous learning (Sung, Hwang, Lin & Hong, 2017). Research stated that the teachers should attempt to incorporate digital pedagogy which will emphasize the worth of Mathematic within the educational process (Ismail, Azizan & Azman, 2013).

Implementing ICT into mathematics is one of the effective learning methods, as the study conducted by Zakaria & Khalid (2016), stated that there are a few advantages of applying ICT in teaching mathematics which can attract students’ interest in learning mathematics, able to increase their motivation and performance, long term learning encouragement and also ease positive interactions and associations. Additionally, teachers can enhance their students' comprehension, stimulate their enthusiasm, and sharpen their mathematical skills by incorporating ICT into their math lessons (Dhayanti Johar & Zubainur, 2018).

One of the qualities that students must acquire in their education, particularly in the study of mathematics, is problem-solving skills. It enhances the area of mathematics that calls for logical thinking, making it one of the most crucial abilities to learn in the subject of mathematics (Khalid, 2017). Students' ability or tactical competence in understanding, selecting approaches and solving solutions, and constructing models to solve the problem is known as mathematical problem-solving skills (Khalid, 2017). According to Amalia, Surya, and Syahputra (2017), there are four fundamental

processes involved in problem resolution: define the problem, create alternative solutions, evaluate and select an alternative, implement and follow up on the solution.

According to Ing, Webb, Franke, Turrou, Wong, Shin, and Fernandez (2015), students are expected to actively engage in the learning process in order to enhance their comprehension of the material. Students' mathematical problem-solving abilities are closely linked to this process. To improve students' ability to solve mathematical problems, an effective model must be incorporated into the teaching process (Amalia, Surya, and Syahputra, 2017). Researchers point out that a major goal of national mathematics education standards and curricular in many countries is the adaptive use of arithmetic procedures and varied mathematical thinking (Nunes, Dorneles, Lin, & Rathgeb-Schnierer, 2016).

Additionally, thinking style have an impact on problem solving, and problem-solving skills are essential for students to develop their knowledge and make contributions in a variety of professions. In order to help students overcome basic problems, learning involves both thinking styles and problem-solving skills (Upu & Sulfianti, 2018). Research by McCormick, Clark & Raines (2015) has found that thinking styles can contribute to problem-solving. Moreover, thinking styles can affect the students' problem-solving skills and perceived motivation (Atasoy & Konyalıhatipoğlu, 2019), stated that different types of thinking styles individuals can produce unique solutions to some problems. The Malaysian Vision (2020) blueprint lends support to this, highlighting that education should not only generate a competitive workforce but also prepare students to use problem-solving skills and advanced thinking styles to overcome challenges (Vicziany & Puteh, 2004).

Hence, this research aims to examine the effect of Mobile Game-Based Leaning (MGBL) application on mathematical problem-solving skills and perceived motivation among different thinking style of Year 4 primary students.

1.3 Problem Statement

Since 1998, the Malaysian Ministry of Education has embraced the use of interactive courseware in instructional strategies as part of the Smart School Project, an educational reform initiative (Jámbor, 2019).

Malaysian Ministry of Education and academic scholars reviewed on the on the implementation of interactive courseware. Courseware uptake, teacher preferences, and student needs were among the evaluation criteria used to measure the level of courseware utilization in teaching and learning. The findings showed that the developed interactive courseware has not been used effectively in schools and that its current uptake has been limited.

A number of factors have been identified as contributing to the low acceptance and usage of courseware. The Common European Framework of Reference for Languages CEFR, an international metric for assessing and characterizing linguistic ability. It offers a methodical framework for evaluating and contrasting linguistic proficiency across various languages was adopted by the Malaysian Ministry of Education in an effort to improve English language competency. Nonetheless, research has revealed difficulties in coordinating foreign English language textbooks with Malaysia's educational goals and CEFR standards. Concerns including contextual fit, linguistic appropriateness, and cultural relevance have been identified (Shak, Albakri, Tahir, & Adam, 2021).

Shak, Albakri, Tahir, and Adam (2021) discussed that, for Malaysian students, imported interactive courseware often fails to have cultural and contextual significance. According to studies, cultural differences and local curriculum goals may prevent children from properly engaging with such resources.

Moreover, At INTI International University, Leow and Neo's (2021) study focuses on using interactive multimedia to improve classroom instruction. According to the study, adding multimedia components enhanced learning outcomes and student engagement. However, these tools' efficacy hinges on how well they match educational goals and cultural relevance.

The above studies collectively underscore the importance of aligning international interactive courseware with Malaysia's national curriculum (KSSR) These studies collectively underscore the importance of aligning international interactive courseware with Malaysia's national curriculum (KSSR) In order to improve educational outcomes in Malaysian classrooms, they emphasize the necessity of carefully considered interface design, culturally relevant material, and the strategic integration of digital resources.

As summary, existing international courseware is not sufficiently adapted to meet the unique demands of the KSSR, and as such, new models of multimedia integration are necessary to improve the effectiveness of digital tools in local educational settings.

To address these challenges, various types of multimedia model could be implemented such, Parnis and Mackay (2020) provide a comprehensive overview of multimedia environmental models which by offering frameworks that specify how various types

of media might be utilized to maximize instructional models and simulations, multimedia models significantly contribute to the teaching and learning.

Despite the contribution of multimedia models in teaching and learning. There were also gaps in the current models which can be improved. To support this, based on research by Wardani, Degeng, and Cholid (2019) on development on interactive multimedia model 4D for teaching natural science subject, the test on 4D development model which consist of definition stage, the design stage, the development stage and the dissemination stages summarise and suggested that the model can be improved mainly on excessive text, varying font styles and sizes, enhancing the background design, using more engaging images, and making slide displays more interesting.

In Mayer's Cognitive Theory of Multimedia Learning by Mayer, (2005), the Mayer's multimodal learning concepts have many drawbacks. They place a strong emphasis on combining text and images, perhaps ignoring alternative learning methods like group projects or hands-on activities. Additionally, since some students may learn better with text or audio, the one-size-fits-all method ignores individual variances in how they receive multimedia (Hinderliter, 2022). The redundancy principle which suggests avoiding needless repetition might not always be the best option because learning can be reinforced by presenting knowledge in a variety of ways, particularly for difficult subjects (Hinderliter, 2022).

Blundell, Mukherjee, and Nykvist (2022) talked about the SAMR (Substitution, Augmentation, Modification, and Redefinition) Model (Puentedura, 2006), a model that focuses on the development of game-based learning which can guide how technology, such as games, is integrated into the classroom. Games can be used to substitute courseware learning methods or redefine how learning experiences are

structured. However, they highlighted the model's shortcomings, including the fact that it doesn't always address content quality, which is essential for assessing the efficacy of game-based learning in education which include in Mathematics learnings.

Mathematics is considered as one of the important knowledge areas in all industries such as science engineering, research development, analytical, finance, medicine, computer science, and many more. Mathematics contributes to all the industries improving their processes in terms of technology and automation (Saward, 2017). Moreover, Mathematics plays an important role in all aspects of our daily life (Krishnasamy, Lew & Tan, 2016). In terms of education, mathematics' main goal is to increase people's lifetime math literacy by developing their mathematical methods, mathematical thinking, and mathematical spirit (Hao & Liu, 2019). It is a fundamental subject for all levels of education starting from kindergarten to higher-level institutions.

According to Gillic (2017), mathematics is an essential life skill that helps young children make them understand world around them. Flexibility in learning Mathematics requires the students to use problem-solving procedures across various representations and in new contexts, which is important for a transferable Mathematical proficiency to lifestyle (Nunes et al., 2016). The capacity to solve problems is at the core of the mathematics curriculum, and mathematics is closely linked to the educational environment to be created as well as the tasks assigned to students (Hassan & Rahman, 2017).

Despite the importance of Mathematics, there have always been reports on the poor performance within the subject in examinations (Acharya, 2017). According to a study done on 30 Year 4 students in Selangor, most students continue to find it difficult to

solve math problems because they can't comprehend the keywords and can't translate them into Mathematical sentence. They also struggle with comprehension of basic concepts and don't enjoy reading lengthy mathematical problems problems (Mokhtar, Ayub, Radhiah, & Said, 2019). A research conducted by Suseelan, Chew, & Chin (2023) with 107 year 4 students from three types of schools, which is National, Chinese and Tamil primary schools located in the rural region of Penang, Malaysia which aim to examine the gap in performance between Year 4 primary students from Malaysia in tackling measurement-based word problems that require higher-order thinking abilities revealed that majority of the students achieve below the minimum proficiency level. The study's findings indicate that teaching strategies should be revised to emphasize a greater value on problem-solving skills and that educational interventions should be implemented in schools to help students develop their problem-solving skills.

This analysis is additional evidence to the claim that, although Mathematics is one amongst the core subjects that included in Malaysia's primary school exams (Shahali, Ismail & Halim, 2017) yet 35% of primary school students have failed the subject, according to the Malaysian Examination Board's annual report (Lembaga Peperiksaan Malaysia, 2018). There are still 21% of primary school students who are still less competent in Mathematics subjects and 16.87% of students still haven’t reached a minimum level in mastering basic knowledge and basic math skills (Petaksiran Sekolah Rendah (KPM), 2019). Furthermore, studies revealed that students were said to struggle with answering mathematical problems (Chinnappan, 2017). In 2022 Malaysian Examination board reported that in the year 2021 27.41% primary school students failed in Mathematics subject (Lembaga Peperiksaan Malaysia, 2022).

Although there is decrease in term of failed percentage the examination board report highlighted that students are struggling with problem-solving that involved more complex concepts and making careless mistakes. In order to improve students' performance, the examination suggested emphasizing the development of students' critical thinking and problem-solving skills as well as making the teaching of mathematics more interesting and relevant to students' lives to improve their performance.

In addition to that, research stated that students were reported to have difficulties in Mathematics problem solving (Chinnappan, 2017). Research among 52 students in a boarding school in Malaysia conducted by Mustafa, Said, Ismail & Tasir (2017), Reveals that high achieving students have a problem in solving mathematical questions, especially in a real-life context. Mostly they only managed to extract important information needed to answer the question but lack of ability to utilize and manipulate the information to solve the problem given.

Furthermore, According to Abdullah, Mokhtar, Abd Halim, Ali, Tahir, and Kohar (2016), demotivation and a negative perception are among the factors contributing to the poor performance of Malaysian students in the mathematics subject on both local and international assessments. These findings highlight the fact that the Ministry of Education's intended goal has not yet been fully achieved. The 2021 Petaksiran Sekolah Rendah Malaysia (PSRA) examinations statistics reported many students do not have a skill on problem-solving strategies that they can draw on when solving problems. This makes it difficult for them to approach problems in a systematic and efficient way and they do not have enough opportunities to practice solving problems in a variety of contexts. This makes it difficult for them to develop the skills they need to be successful problem-solvers (Petaksiran Sekolah Rendah (KPM), 2021).

The cause of these problems is a lack of motivation to learn Mathematics, as well as a perception among students that Mathematics is complicated to understand (Hashim, Hashim & Ahmad, 2019). This is due to the existing method (courseware method) that is being used to teach Mathematics in the classroom (Lessani, Yunus & Bakar, 2017). Therefore, a need to find alternative methods for additional learning to improve Mathematical problem-solving skills is required (Mustafa et al. 2017). It is claimed that applying ICT in teaching and learning Mathematics increases their motivation and performance (Zakaria & Khalid, 2016).

Technology-based learning especially Game-Based Learning (GBL) is an effective approach for enhancing students' motivation and performance (Eltahir, Alsalhi, Al-Qatawneh, AlQudah, & Jaradat, 2021). Particularly in Mathematics, the alignment of instructional and game design elements has a significant influence on how effectively students learn the subject. (Tokac, Novak & Thompson, 2019). According to a study conducted by Ling (2018), Students' motivation determines their participation in the game, which in turn determines their ability to solve complex problems. The nature and design of the gaming assignment also had a significant impact on the students' motivation, engagement, and problem-solving skills.

In addition to completing Math exercises from a book, students can play mathematical educational games as an extra practice to strengthen their Mathematical problem-solving skills (Hwa, 2018). Digital games can offer an enjoyable and stimulating learning environment for specific subjects related to problem-solving (Huang, Kuo & Chen, 2020). Learning through digital games would provide an exciting and motivating strategy for solving problem-solving questions. According to Stoyanova, Tuparova & Samardzhiev (2016), game mechanics and game thinking engage people and help them solve problems.

According to Vlachopoulos & Makri (2017), using a mobile application to integrate GBL into lessons can inspire students and allow them to engage with a variety of learning styles. Through implementing new teaching and learning, teachers able to resolve important issues associated with the adjustment of the educational process among students where integration of GBL and mobile application could provide a new learning style among students. While problem-solving is widely acknowledged to be important, the way to teach and improve it as well as the factors associated with problem-solving are still unknown (Lester & Cai, 2016).

Nevertheless, when solving problems, thinking is a necessary step. People frequently apply act of thinking to overcome problems they encounter in their daily lives or at school. People tend to prefer methods, such as styles of thinking that are comfortable for them when using their problem-solving skills (Nasukhah, 2020). Research stated that thinking styles have an influence on Mathematics problem solving (Fauzi, Usodo & Subanti, 2017). Yagci (2016), claimed that thinking styles affect motivation as well which will lead to perceived motivation in learning Mathematics.

Addressing the identified gaps, this research aimed to explore a modified approach to learning the Year 4 Primary Mathematics syllabus. It specifically investigated how mathematical problem-solving abilities and perceived motivation across various thinking styles were affected by a multimedia model that included computational thinking which integrates game-based learning (GBL) application. The rationale for choosing Year 4 is it is essential to concentrate on Year 4 pupils in order to improve their maths skills because this year is a significant transition when the foundational skills must be established. In order to ensure that pupils are sufficiently prepared for the demands of upper primary school, national exams, and beyond, early intervention, focused instruction, and attention to this developmental stage will have long-lasting

effects. By supporting Year 4 students' mathematical education, teachers may create solid foundations that will help kids succeed academically, cultivate a love of mathematics, and advance national educational objectives (Mokhtar, Ayub, Said, & Mustakim, 2019).

1.4 Research Objective

The main purpose of this research was to investigate the effectiveness of mobile game-based learning application to improve students' Mathematic problem-solving skills and perceived motivation in Mathematic learning among Year 4 students of different thinking styles. Thus, the objectives of the study are as follows:

1) To identify relevant components for the MGBL application development

2) To design and develop a MGBL application based on component in objective 1

3) To investigate the effectiveness of MGBL application on Year 4 students's mathematical problem-solving skills & their perceived motivation of instructional material.

4) To examine the interaction effect of different thinking styles on the use of MGBL application to improve students' problem-solving skills and their perceived motivation.

1.5 Research Questions

This research was to design to address the following research questions:

1) What are the relevant components for the mobile game-based learning application to improve students' mathematical problem-solving skills and their perceived motivation?

2) How do these components interrelate into the design and development of a mobile game-based learning application that can improve students' mathematical problem-solving skills and their perceived motivation?

3) What is the effectiveness of the multimedia model used in mobile game-based learning application that can improve students' mathematical problem-solving skills?

4) What is the student's perceived motivation on the instruction material?

5) What is significant effects of students' thinking style on their mathematical problem-solving skill?

6) What is significant effects of students' thinking style on their perceived motivation of the instructional material?

1.6 Research Hypothesis

Four research questions were designed to achieve the aim. From these research questions, three hypotheses were formulated. For research question 1, 2 and 3 there is no hypotheses as the questions has been answered in chapter 3 and 4. Hypotheses for research question 3, 4, 5 and 6 are formulated as a null hypothesis as below:

H_{03}: There is no effect of using ROMAAD application on the improvement of students' mathematical problem-solving skills.

$H_{04:}$ There is no significant interaction of the students' thinking styles on the use of ROMAAD application to improve students' problem-solving skills.

H_{05}: There is no effect of using ROMAAD application on the students' perceived motivation for the instructional material.

H_{06}: There is no significant interaction of the students' thinking styles on the use of ROMAAD application on their students' perceived motivation of the instructional material.

1.7 Significance of the study

In the current digital era, younger generations were exposed to technology. They prefer to engage themselves with digital methods even into the learning process via MGBL. This study was significant as it as aims to investigate the effectiveness of MGBL application in improving mathematics problem-solving skills and perceived motivation with different thinking styles. The MGBL method was chosen to associate the younger students with a fun learning experience. Based on literature reviews MGBL application elements were proven to improve students' interest and motivation in learning as it engages with fun elements and diverse learning styles.

Through this study a new Computational Thinking (CT) model which integrates with GBL has been applied in this MGBL application. This new integration of two emerging fields, CT and GBL, in the MGBL application contributes to the body of knowledge on multimedia models. It has the potential to be applied in mathematics education and could serve as an alternative to the current courseware-based learning methods in schools.

Students were benefited from this MGBL application in terms of enhancing their mathematical problem-solving. This is because playing games requires the player to make quick and smart decisions and when these skills are applied in Mathematics learning, it helped the students to improve their Mathematics skills. MGBL was able to produce an independent and self-reliant student. They was able to learn and practice Mathematics questions on their own, via the MGBL application compared to the courseware learning method. It could also be beneficial for instructors in terms of gaining students' attention and engaging them in the learning process by using the MGBL application. During self-learning and practice Mathematics questions, the

instructor can conduct extra observation and upskill the students for independent learning for Mathematics subjects using the MGBL application. This helped to increase learners' ability in problem-solving questions. MGBL application also provides a convenient learning opportunity outside the classroom as the lessons can be learned anytime and anywhere.

In addition to that, this approach for learning Mathematics, make it easier for parents to guide and encourage their kids to revise/practice/learn on their own under their observation. It also benefits working parents who don't have enough time to spend with their kids during home revision time. This MGBL approach motivated the kids to revise and practice on Mathematics questions in the absence of the parents and the parents are also able to check on the progress of their kids through the scores and rewards in the game. MGBL approach could benefit the parents who have no financial strength for extra private classes as the students are able to learn and practice Mathematics questions on their own with the tutorial videos.

Furthermore, the outcome of this research contributed to the findings and evidence to the Ministry of Education (MOE) for implementing MGBL application in the education system. Results of this research were able to support future research on the students' performance in Mathematics. Not only that, but this research also contributed to further research on improving Mathematical problem solving and motivation of different thinking styles students.

Table 1.1

Summary of Significance of study

Theory	Better framework in developing MGBL application to be implemented among students
Methodology	Steps in instructional material development based on methodology adopted from previous studies.
Practicality	A new learning implementation with Malaysia Year 4 syllabus
Beneficiaries	Year 4 students, Parents, Teachers & Ministry of Education (MOE).

1.8 Definition of Operational Terms

Game-Based Learning

Game-based learning is an innovative learning method that incorporates games into teaching and learning. Game elements, components, and game principles will be applied to learning activities to offer a fun and enjoyable learning process, particularly for the younger generation of students. Learning will be more engaging by including components such as storyline, game elements, scoreboard, rewards, tutorial videos, assessments, and feedback.

Problem Solving Skills

Problem-solving skills broadly refer to the ability to overcome difficulties and the ability to see and solve problems by applying the skills comprehensively. Problem-solving skills also can define as the capability to solve the problem effectively and efficiently without any obstacles or negative impact. It involves terms of identifying

the problem, the reason, finding solutions, evaluating the solution then coming out with the best solution to the problem and implementing the solution.

Mobile Application

A mobile application is an application installed in mobile/smartphones which developed using specific software. It provides interactivity to the users in terms of playing games which can store the game information in the application.

Mathematics Year 4

Mathematics Year 4 is a part of the mathematic learning process that covers Malaysia's primary school syllabus is suitable for year 4 students. Some of the topics covered in the syllabus are addition, subtraction, multiplication, division, fraction, and more.

Mathematics problem-solving skills

Mathematics problem-solving skills are a skill required to learn in mathematics that needs to be solved with specified methods. To solve the question, students must be able to understand, develop a solution and evaluate it. The sub-component of problem-solving skills can be stated as to define and understand the problem, which is to read on the comprehension Mathematics question, devise the plan which is to identify the proper solution, carry out the plan which means solving the question and revise which can be interpreted as going through the solution.

Perceived Motivation

Perceived motivation can be classified as a positive perception, sustaining behavior, interest, and stimulating students to keep practicing the intervention. The subcomponent of perceived motivation is attention, confidence, relevance, and satisfaction. Attention specifies as an increase of motivation level to learn

Mathematics when capturing the interest of respondents. The responders' level of motivation will rise as they feel more confident and capable of succeeding. Relevance is when respondents perceived it is meaningfully related to their needs and goal. Whereas satisfaction helps to raise motivation level when reinforcing accomplishment with the reward for a successful result.

Thinking Style

Thinking style refers to a way or techniques students used to implement in forming a view and processing or analysing information in certain situations. There are two types of thinking style: holistic thinking and analytical thinking.

Holistic Thinking

Holistic Thinking is the ability to view Mathematical problem-solving questions as a whole during providing solutions. Students who scored 9-15 in SOHAT are the ones who have a holistic thinking style.

Analytical thinking

Analytical thinking is students who have the ability to solve Mathematical problems part by part according to obtained knowledge. Students who scored 5-8 in SOHAT is the one who has a holistic thinking style.

1.9 Summary of the study

This chapter consists of the research introduction, background, and problem statement, objectives of the research, research questions, and the significance of the study. All the elements were described in detail to clarify the main purpose of this research. The definitions of the operational words used in this study concluded the chapter. The next chapter emphasis on the literature review that will further improve the understanding by helping to identify gaps for this study through previous related research.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter provides an overview of previous studies related to this research and helps to highlight new research streams. This chapter also helps to identify and recognize the gap of the area which can contribute to this study. The outline of this chapter will focus on previous studies of data which support the integrity of the theories and models that will be used in this study and to identify the research gap that exists within Mobile Game-Based Learning (MGBL) application in Mathematics learning.

2.2 Learning Courseware in Malaysia

In Malaysia, particularly in primary schools, the incorporation of courseware into education has increased in significance. The term "courseware," which describes software applications created for educational purposes, aims to improve learning outcomes and increase student engagement.

The Smart School program and Frog VLE are two notable initiatives that aim to digitalize learning materials and provide interactive learning experiences (Ministry of Education Malaysia, 2019). The Malaysian Ministry of Education (MOE) has been actively promoting the use of Information and Communication Technology (ICT) in classrooms, which has resulted in the development and deployment of various educational courseware.

Several studies have highlighted the benefits of courseware in primary education. Despite the advantages, there are notable challenges in the implementation of

courseware in Malaysian primary schools. One of the major issues with courseware in Malaysia is its alignment with the national curriculum. This has been supported by research conducted by Ahmad and Aziz (2020) indicate that some courseware fails to fully correspond to the curriculum criteria issued by the MOE, leading to discrepancies in learning objectives.

The quality of content varies significantly among different courseware providers. As a primary teaching tool, some courseware is less effective since it is brief and does not cover topics thoroughly (Zulkifli et al., 2022). Concerns are also raised by out-of-date material that does not follow contemporary trends in education. According to Nordin & Jamal, (2021). Sometimes courseware information is not localized, which makes it harder for students to relate to. Research indicates that certain course materials contain case studies and examples that are suitable for Western settings than for Malaysian culture, reducing student engagement and comprehension.

In certain courseware the multimedia components enhance engagement, excessive reliance on animations and graphics without sufficient textual explanations can hinder deep learning. According to research by Lim and Tan (2023), too much multimedia may divert students' attention from learning material.

While courseware holds significant potential in enhancing the learning experience in Malaysian primary schools, its effectiveness is often hindered by content-related challenges. Ensuring curriculum alignment, addressing language barriers, maintaining high-quality and culturally relevant content, and balancing multimedia usage are critical for improving courseware implementation. Future research should focus on developing more adaptive and inclusive courseware tailored to the diverse needs of Malaysian students.

In the Malaysian Online Journal of Educational Technology by Kamaruddin (2015), article on "Understanding Patterns of Interactive Courseware Use in Class Within Malaysian Primary Smart Schools" examines the difficulties and usage trends of interactive courseware in Malaysian primary schools. It points out problems with user engagement and curriculum alignment, two things that are essential for implementing a successful learning element.

To make learning more engaging and interactive, courseware need to be enhanced with integration other multimedia content into subjects like science, and Bahasa Malaysia and Mathematics. (Kamaruddin, 2015).

According to research by Tan and Rosli (2021), the majority of the content discussed in the updated KSSR Standard 4 mathematics textbook were in line with the TIMSS 2019 mathematics framework; nevertheless, several topic areas and content domains did not reach the minimum percentages required by the framework. Considering the national curriculum's emphasis on higher-order thinking skills (HOTS), this implies that current course materials might not be entirely in line with it.

Although interactive courseware increased student involvement and comprehension, Hashim et al. (2024) pointed out that its creation necessitated careful modification to meet curriculum requirements.

2.3 Mathematics

Mathematics subject is a foundation for basic knowledge in most industries such as science engineering research development, analytical, finance, medicine, computer science, and more (Develaki, 2020). Mathematics education and its adaptability is a very important aim of National Mathematics Education Standards and Curriculum in

many countries (Seah, Kim, & Kim, 2021). In Malaysia, one of the required fundamental subject to be taken for the exam is Mathematics.

According to Ahmad (2019), Mathematics is applied everywhere, and literally, Mathematics is very vital in our daily lives. Mathematics holds a role to develop a person in terms of creativity, responsiveness to surrounding physical, improving investigating and problem-solving skills (Santos-Trigo, 2020).). However, studies show that students face difficulties in Mathematics subject, and it's lead to poor performance in their education (Harefa, 2023). Moreover, Malaysia primary school students' tend to not favoring in learning Mathematics and are always subject to a high level of anxiety and this can influence students understanding of mathematics (Qasim, Khalaf, Abdulkareem & Yussop, 2018). This can lead to a lack of Mathematics skills among students (Firdaus, 2017). Despite the transformation of education in Malaysia, students' performance in mathematics has persistently been poor (Alhassora, Abu & Abdullah, 2017). Such issues need to be addressed because apart from being a fundamental subject in the school curriculum system, the Mathematics subject has also a requirement of most disciplines in higher education institutions (Fitzpatrick & Sovde, 2019).

As for the solution, students' needs to be proficient in Mathematics skills mainly in problem-solving skills (Widodo & Ikhwanudin, 2018). Surya and Putri (2017), claimed that is Mathematical problem-solving plays a major part in learning and achieving in Mathematics. Thus, a suitable learning method that can help to improve problem-solving skills should be implemented to attract the students' mainly younger students. The progression of Mathematical problem solving can provide students with

various thinking abilities such as logical, analytical, systematic, critical, and creative (Surya and Putri, 2017).

2.4 Problem-solving Skills

Previous literature on Mathematics emphasized that enhancing problem-solving skills is necessary. to be achieved in Mathematics (Darmawan & Suparman, 2019). Problem-solving skills generally refers to the ability to cope with difficulties and it is the ability to spot and solve problems by applying skills thoroughly with various thinking ability (Szabo, Körtesi, Guncaga, Szabo & Neag, (2020). Problem-solving may be a process—an ongoing activity within which we take what we all know to get what we do not know (Puccio, Klarman & Szalay, 2023). They are many studies that were conducted based on these skills concerning education and learning. Latest studies showed that problem-solving skills have two aspects which are rule identification and rule application as it refers to the concepts in problem-solving on sense control the processes, the attitudes, or the actions (Shute & Emihovich, 2018). The ability to gather knowledge about the problem-solving environment is referred to as rule identification, whereas the ability to manage the problem-solving environment is referred to as rule application (Shute & Emihovich, 2018).

Problem-solving is a vital life skill that requires each problem solver to develop an appropriate answer to a circumstance that is unique and original to them (Hassan & Rahman, 2017). Moreover, understanding the problem, establishing a plan, applying a problem-solving technique, and devising a solution are all actions that the skill encourages students to participate in actively. According to Karatas, (2022), students can improve their conceptual understanding, procedural fluency, strategic

competence, productive disposition, and capacity for flexible thought by using problem-solving skills..

Students who do not understand the problem-solving process (PSP) will face challenges to establish a complete PSP (Fitzsimons, 2021). Based on a discussion paper by Faulkner, Breen, Prendergast & Carr, (2021), It can be determined that students' problem-solving performance is statistically lower. Problem-solving skills are the essential ability required by the present students and also problem-solving skills is the fundamental point of Mathematic education (Novriani & Surya, 2017) and it plays a major part in learning and achieving in Mathematics (Surya & Putri, 2017). Guinungco and Roman (2020), pointed out that problem-solving skills are significant in students' performance, specifically in Mathematics. Students' problem-solving skills may affect their participation in problem-solving steps when they try to solve mathematical problems.

2.5 Mathematics Problem Solving skills.

Mathematics problem solving can be defined as a student's skill working on problem-solving questions. Mathematics problem-solving skills, experiences, mathematics background, motivation/willingness, and issue structure are all elements that influence students. (Yadnya, Ardana & Suharta, 2020). Mathematical problems are very complex that causing students to find it difficult to solve them (Ulandari, Amry & Saragih 2019). Furthermore, a study conducted by Simamora, Sidabutar, and Sury (2017) among 30 junior high school students on the improvement of learning activities and problem-solving skills of mathematics subject in class, claimed that the improvement in problem-solving skills can enhance student learning, and thus will help to improve Mathematics education as well.

According to Maass, Geiger, Ariza, and Goos (2019), mathematics subjects also support in the development of problem-solving skills by employing Mathematical problem-solving questions. Research indicates that students' problem-solving skills in real-world situations are deficient (Incebacak & Ersoy, 2019).

Figure 2.1 shows the components in problem-solving skills which was used as an indicator in a study conducted by Novriani and Surya (2017) in identifying students' difficulties in Mathematics problem-solving ability.

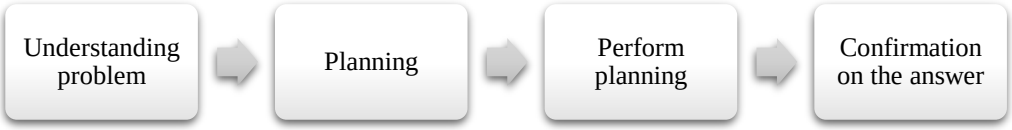


Figure 2.1. Component in Mathematics Problem solving skills.

One of the endpoints in learning and teaching Mathematics is mathematical problem solving (Duque & Tan, 2018). To eliminate problem-solving skills issues, schools level education system should be contribute to provide solution.

A suitable and interesting learning approach should be implemented in Mathematics education where students are able to improve their problem-solving skills (Novriani and Surya, 2017). Action research by Nizaruddin et al (2017), on the resolving problem-solving ability of students in mathematics through game-based learning activities, stated that there is an increase in the problem-solving skills and learning outcomes of the students because the students were able to understand and respond to the teachers' game-based learning. In addition, during the learning process, questions and answers led to new suggestions for students to complete the task.

The study revealed that game-based learning was able to improve their competitive spirit to achieve good grades and to get the best result in the competency test using

their problem-solving skills. Thus, the thought process was much richer. It also has been concluded that there is an increase in the students' problem-solving abilities through implementing GBL in Mathematics learning. Therefore, GBL was a solution to eliminate problem solving skills issue.

2.6 Game-Based Learning

The modern society's shifting technological and social environment necessitated the development of new professional competencies known as "21st-century skills." These abilities should be developed and implemented in primary school because they are behavioral and psychological rather than practical. One of the most successful methods for developing this 21st-century skill is game-based learning (Liu, Shaikh & Gazizova, 2020). A platform that encourages students to study as they play while learning is more engaging by including enjoyable aspects into the curriculum is known as game-based learning (GBL). (Al- Azawi, Al-Faliti & Al-Blushi, 2016). Studies have proved that GBL uplift critical and strategic thinking which able to increase students' engagement level (Yu, 2018), the learning process in an interactive way (Sodiqovich, Burxonovich, & Mamarasulovich, 2020), increase students' motivation, and enhance learning retention (Figueroa-Flores, 2016).

In addition, Qian and Clark (2016) stated that GBL and 21st-century aptitudes have been picking up a gigantic sum of consideration from analysts and specialists. Given various investigations uphold the beneficial outcomes of games on learning, currently educational games are being created to advance students' 21st-century expertise improvement in schools. When games are meant to address a specific issue or demonstrate a specific aptitude and skill, the GBL has been a great achievement. Scholars have been using games in education for a variety of reasons, including the

reasons listed why games are effective teaching and learning tools. (AzawiR., Al-Faliti & Al-Blushi, 2016). Use of the game in education declare that *"games are built on sound learning principles; games provide more engagement for the learner; games provide personalized learning opportunities; games teach 21st-century skills; games provide an environment for authentic and relevant assessment"* (AzawiR., Al-Faliti & Al-Blushi, 2016, p.133).

Furthermore, Hamari, Shernoff, Rowe, Coller, Asbell-Clarke, and Edwards (2016) studied immersion and involvement in learning in a GBL environment, the result showed that GBL has given a positive outcome on engagement and impact on learning. The research was conducted in the United States among 134 high school students, namely in 11 classrooms, who participated in Quantum Spectre as part of their Physic Unit on Optics. The influence of the game on the achievement of learning by learners can be seen from the differences in learning results for those who have studied through the game and those who have used textbooks (Setyaningrum, Pratama, & Ali, 2018).

All, Castellar & Van Looy (2015) stated that GBL involvement in the learning process is successful. The analysis shows that GBL emphasizes on the rise of attention and importance in the subject matter and there is improvement in target execution (e.g., in a test); as the GBL alluded to the player's capacity to apply obtained information or abilities to real-world circumstances. An educational game should be designed in terms of challenging elements to ensure the learners can grow their capacity and learning to endorse continued learning in game-based learning methods (Hamari et al, 2016). Eltahir, Alsalhi, Al-Qatawneh, AlQudah & Jaradat (2021), indicate the endmost goal of the GBL is to solve problems, motivate and engage students and

encourage learning using game-based thinking and techniques. GBL can be implemented in various approaches such as online games, mobile, standalone (PC), consoles, arcade, and more (Jossan, Gauthier & Jenkinson, 2021). Among the platforms indicated, mobile has the most attractive learning reasons, therefore it could be an appropriate platform for learning (Aznar-Díaz, Hinojo-Lucena, Caceres-Reche & Romero-Rodríguez, 2020).

Besides that, Figueiredo, Godejord, Rodrigues, and Gozáles-Pérez (2016) stated that students who struggle to catch topics covered in class may then be able to study and practice as many times they want anyway at any time. A study by Gunawan, Bahari, and Kartiwi (2017) on developing a Mathematics educational game for primary school students also mentioned that educational games attract students and help to gain attention in learning Mathematics subjects and the result reveal that educational games improved students Mathematical learning. Moreover, research carried out by Hashim, Hashim, and Ahmad (2019), on implementing the educational game application in improving Mathematics learning among third-grader primary school students in Selangor Malaysia proven that Mathematics game application helps low-performance students specifically in improving their Mathematical skills. As for this study, the implementation of the GBL application via mobile will be conducted to investigate Mathematics problem-solving skills among Year 4 students to improve their problem-solving skills and perceive motivation with two different thinking styles.

Table 2.1 *Summary of GBL*

Title	Author	Sample	Findings
Development of educational game for primary school mathematics using Microsoft Kinect	Gunawan, Bahari, and Kartiwi (2017)	Primary school students (Year 1-3)	Educational games attract students and help to gain attention in learning Mathematics subjects and the result reveal that educational games improved students Mathematical learning
Educational Game Apps In Improving Students Mathematics'learning: An Exploratory Study On Third Grader At-Risk Classroom At Primary School In Selangor	Hashim, Hashim, and Ahmad (2019),	Primary school students	Mathematics game application helps low-performance students specifically in improving their Mathematical skills
Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning	Hamari, Shernoff, Rowe, Coller, Asbell-Clarke & Edwards (2016)	High school students	The result showed that GBL has given a positive outcome on engagement and impact on learning
Game-based learning in problem solving method: The effects on students' achievement	Setyaningrum, Pratama, & Ali, 2018	High school students	Different learning results from the influence of the game on the achievement of learning between those who have studied through the game and those who have used textbooks
Towards a conceptual framework for assessing the effectiveness of	All, Castellar & Van Looy (2015)	33 Stakeholders (from 3 different areas)	GBL emphasizes on the rise of attention and importance in the subject matter and there is improvement in

digital game-based learning			target execution (e.g., in a test)
The impact of game-based learning (GBL) on students' motivation, engagement and academic performance on an Arabic language grammar course in higher education	Eltahir, Alsalhi, Al-Qatawneh, AlQudah & Jaradat (2021)	107 university students	The endmost goal of the GBL is to solve problems, motivate and engage students and encourage learning using game-based thinking and techniques

2.7 Mobile Game-Based Learning

Smartphones, feature phones, pocket PCs, and tablet PCs are all types of mobile devices suited for playing mobile games. (Huang & Burgos, 2020). Since mobile games have become a place for innovative, modern play and game design methods, the rise of mobile gaming is significant, both in terms of quantity and quality (Dziedzic, 2016). As mobile technology's usage and capabilities grow, mobile apps and services are expected to become more sophisticated, with context-aware features that mix gaming with other benefits such as learning, fitness, or marketing.

Mobile devices bring numerous benefits for our everyday routine and quality of life (Shukri, & Ariffin, 2020). Since education is the primary catalyst in our life, it should be advantageous to all fields, including education (Huizenga, Admiraal, Dam, & Voogt, 2019). A study conducted by Omar (2017) on the phenomenon of children who are obsessed with technology reveals that that younger generations perceived and consider their mobile phones to be a vital entertainment tool in their daily life. Consequently, educators should take advantage of this chance to transform this instrument into a teaching tool. (Shukri & Ariffin, 2020).

An analysis of past research published by Masrom, Nadzari, Mahmood, Zakaria & Ali (2016) on mobile learning in Malaysia education institutions summarized that mobile learning is suitable for all education levels including primary school level due to its positive impact and interest toward mobile learning among students.

Drigas and Pappas (2015) claim that mobile learning is considered as future learning because it is an area that has quick development. Learning through a mobile application allow students to explore many things in term of functions and practicing on numerical and mathematical skill. Furthermore, in Mathematics learning and teaching, Alkhateeb (2019) reveals that students are able to receive educational support in Mathematics subjects from the usage of mobile games and it classifies as an effective method, while a well-designed mobile game can help students realize high achievement in mathematics. And also, teacher can assign homework and exercise to the students use mobile as it has been researched that the students would love to play games on mobile which will encourage them to practice Mathematics questions (Chang & Yang, 2016). Troussas, Krouska, and Sgouropoulou's (2020) research indicates that integrating mobile game-based learning can enhance students' educational experiences and help them increase their knowledge. The study also analyses the pedagogical affordance of adopting these technologies in higher education settings.

According to some researchers, implementing alternative learning activities can increase students' awareness of their preferred learning styles and motivate them to take on responsibility. These activities also include different modes of assessment. For example, Mustika, Kao, Siswanto, Cheng, Heh, & Chang (2015) introduced a vocabulary assessment mobile learning game for learning new languages. The usage

of mobile devices for game-based learning to improve student comprehension and the effectiveness of the educational process is expanded further in this study. The study showed that MGBL assessments assist in alleviating students' stress and anxiety and that an effective educational game design must mix play value with educational value. Vidal, Ty, Caluya, and Rodrigo's (2018) study adds an additional piece of evidence in favour of mobile device use for game-based learning. The researchers claimed that students successfully acquired the domain knowledge through the MGBL environment and that such technology improvements could increase the efficacy of the teaching process.

Table 2.2

Summary of MGBL

Title	Author	Method/Sample	Findings
Mobile learning in Malaysia education institutions	Masrom, Nadzari, Mahmood, Zakaria & Ali (2016)	Previous researches gathered and analyzed	Mobile learning in Malaysia is suitable for all education levels including primary school level due to its positive impact and interest toward mobile learning among students
Teachers' beliefs about the nature, teaching and learning of mathematics and sources of these beliefs	Alkhateeb (2019)	Primary (4th graders)	Students are able to receive educational support in Mathematics subjects from the usage of mobile games and it classifies as an effective method
Collaboration and fuzzy-modeled personalization for mobile game-based learning in higher education	Troussas, Krouska, and Sgouropoulou, (2020)	Higher Education students	Students' education can be further supported by Mobile game-based learning to increase their level of knowledge.

A mobile-phone camera text-recognition game as an alternative assessment in vocabulary instruction for learning Indonesian as a foreign language classroom	Mustika, Kao, Siswanto, Cheng, Heh & Chang (2015)	Foreign language students	This study aims to improve the efficacy of education by utilizing mobile technologies in game-based learning.
MAGIS: mobile augmented-reality games for instructional support.	Vidal, Ty, Caluya, and Rodrigo (2018)		MGBL has been shown to increase the effectiveness of the teaching process and demonstrate that students have successfully acquired the domain knowledge.

2.8 Mathematics learning via Mobile Game-Based Learning Application

Research carried out by Masrom, Nadzari, and Zakaria (2016), reveals that learning through mobile can be independent in terms of time and place where it can provide more learning opportunities and learning resources to students anywhere at any time to make an innovation in the educational process. Therefore, mobile could be the suitable platform to increase the effectiveness of the GBL application Mathematics subject. Moreover, the study concluded that mobile learning applications are needed in Malaysia to help the education process and enhance the learning process itself.

In addition, Chang & Yang (2016) conducted a study on the effectiveness of MGBL application for Mathematics subjects among middle school students. The study focuses on Mathematics abilities such as Geometry, Logic, questions solutions, and Graphics and Space. The result of the study revealed that Mathematics learning Applications can enhance the effectiveness in learning, and they also can become remedial teaching materials.

Based on research by Al-Khateeb (2019), the findings of a study on the impact of mobile gaming on mathematical achievement among 66 fourth graders indicated that using mobile games for educational support to kids in mathematics is a beneficial practise. Furthermore, the impact of playing mobile games was significant.

Halloluwa, Vyas, Usoof & Hewagamage, (2018) conducted a case study on 130 primary school pupils were tested on a tablet-game-based programme that was similar to a mobile game for math learning. The research examined at how students' performance influenced their ability to read and write problem-solving questions and responses. The findings indicate that tablet-game-based applications have the potential to improve students' learning experiences.

Additionally, research on the effects of mobile games, technological innovation, and collaborative learning on students' motivation indicates that embedding mobile games with learning is seen as a critical component of students' motivation (Mivehchi & Rajabion, 2020). Therefore, this study also attempts to investigate the effect of MGBL on two dependent variables: Mathematics problem solving-skill and perceived motivation.

Table 2.3

Summary of Mathematics learning via Mobile Game-Based Learning Application

Title	Author	Sample	Findings
Implementation of Mobile Learning Apps in Malaysia Higher Education Institutions	Masrom, Nadzari, and Zakaria (2016)	Higher Education students	Mobile could be the suitable platform to increase the effectiveness of the GBL application Mathematics subject
Developing a mobile app for game-based	Chang & Yang (2016)	Middle school students	Mathematics GBL can enhance the

learning in middle school mathematics course			effectiveness in learning and they also can become remedial teaching materials
Teachers' beliefs about the nature, teaching and learning of mathematics and sources of these beliefs	Al-Khateeb (2019)	Primary (4th graders)	Using mobile games for educational support to kids in mathematics is a beneficial practise. Furthermore, the impact of playing mobile games was significant
Gamification for development: a case of collaborative learning in Sri Lankan primary schools	Halloluwa, Vyas, Usoof & Hewagamage, (2018)	130 primary school	Tablet-game-based applications have the potential to improve students' Mathematics learning experiences

2.9 Perceived Motivation through Mobile Game-Based Learning

"The process whereby goal-directed activity is encouraged and sustained" is how Nikou and Economides (2016) describe motivation. One of the major aspects of well-organized education is the development of motivation (Harandi, 2015). Progress in technology have made old teaching approaches have become obsolete due to the introduction of new ones, which fail to appropriately adjust to contemporary trends and cause students to lose interest in what they are teaching and learning (Chin, 2017). Current younger generations and students are in digital age as they are familiar with various type of electronic devices and digital. Thus, the adaption of new technologies in the learning processes can contribute to a positive motivational outcome (Chin, 2017).

Hamari et al, (2016) mentioned that much previous research concluded that students who are learned via game-based learning tend to have higher motivation when they perceived themselves to be competent. Partovi and Razavi's (2019) examined the impact of game-based learning (GBL) on academic success motivation in 60 elementary schools, comparing the outcomes of students in the experimental group and the control group. The result showed that game-based learning impacted students' motivation toward academics in contrast to students in the control group who implemented the conventional teaching method.

Wu (2018), integrated the ARCS model designed by Keller (1983, 1984, 1987) with mobile game-based learning by constructing a mobile game-based practice system. The study classified students into two groups which are using exiting method groups and game-based groups. The game-based group was implementing the mobile game-based practice system. The post-test score of the game-based group revealed that digital game stimulated their participation and learning motivation. Moreover, the outcome of learning motivation, shows that students received positive responses in the ARCS model by Keller (1983, 1984, 1987) namely attention, relevance, confidence, and satisfaction.

These studies have contributed important insights for the implementation of motivation aspects in MGBL application design and development.

2.10 Computational Thinking & Game-Based Learning Model (CTGBL)

A modern approach to improve students' mathematical problem-solving abilities is the incorporation of Computational Thinking (CT) into Game-Based Learning (GBL). A CT model incorporated in GBL was proposed by Annamalai, Omar, and Salam (2024)

to fill up the gap left by models that don't include a systematic framework for integrating CT into the teaching of mathematics. Their study found that deconstruction, pattern identification, abstraction, and algorithm design—all crucial for CT and efficient mathematical problem-solving—were necessary for such a model.

To ensure that game-based activities not only keep students interested but also strengthen Mathematical concepts presented in educational curricular, the authors underlined the significance of matching GBL tactics with curricular standards. This alignment is essential for GBL's smooth integration into conventional teaching techniques and for optimizing its capacity to raise students' mathematical proficiency (Annamalai, Omar & Salam, 2024).

Additionally, to ensure that GBL tools are beneficial in improving CT skills, Annamalai, Omar, and Salam (2024) emphasized the necessity of their iterative development and validation. Teachers and policymakers can use their approach as a guide to create and implement pedagogically sound GBL resources that are in line with learning goals.

This CTGBL model was referred as foundational model to develop the MGBL application. However, this model was not sued directly.

2.11 Thinking Style

Variables of individual differences in human performance refer to the concept of style (Sternberg, 1997; Zhang & Sternberg, 2000). An individual's potential to solve specific problems, think, perceive, and remember in a way that familiar can be defined as style (Riding & Cheema, 1991). In addition to that style is also refers to a method that individuals choose to use while doing or thinking about something (Sternberg,

1997). Sternberg (1988) defines a thinking style as a way of thinking based on an individual's preferred thinking style.

Atasoy & Konyalıhatipoğlu (2019), states that a person can have various ways of thinking about a situation or problem and can use their dominant style when compared to specific situations. Therefore, allowing an individual to apply their dominant thinking style will have high chances to succeed in the task and solving a problem. In order to lead better lives, students are taught how to use and employ the power of thought. It appears to have an impact on comprehending and applying thinking techniques as a preferred strategy of evaluation, judgment, and reasoning in various spheres of life.

Cognitive activity is a thinking way that will happen in people's minds or mental to solve problem-based situations and finding a solution is always connected to the problem. (Solso Maclin & Maclin, 2007). Sternberg and Grigorenko (2001) define thinking styles as individuals' styles. It is a way they prefer to perform a particular task; it was referring more to degrees rather than to certain categories of preferences which is high and low levels according to the dimension of thinking which is addressed in the categorization of thinking style. In Sternberg's theory (1997) in level dimension, individuals are categorized into two groups which are global and local. Individuals who have local thinking style ability is dominant in prefer to concentrate on details, specific and concrete examples. Those who are with the global thinking style dominant are found to observe and consideration of certain situations or problems overall by dealing with generalizations and abstractions. Local thinking is considered as the person who is with analytical thinking and global is with holistic thinking ability.

2.11.1 Analytical Thinking

Analytical thinking involves logical principles to achieve a result and that uses the strong indication. Students distinguish the problem from the different parts and features in the attempt of reaching the result. Individuals with an analytical thinking style tend to process and information or solve a problem linearly, sequentially, and regularly as they break up and analyze the information or problems through individual analysis and decomposition (Atasoy & Konyalıhatipoğlu, 2019). Students who are analytical thinkers will indicate their preferences for externalized formal representations and internalized formal imaginations in this study. They tend to prefer following a set of steps and will prefer to comprehend mathematical concepts best through verbal or symbolic representations already in existence. (Huincahue, Borromeo-Ferri, Reyes-Santander & Garrido-Véliz, 2021).

2.11.2 Holistic Thinking

Individuals who have holistic thinking focus on details when they looked at the general picture and understand the situation of the problem. Individuals with a holistic thinking style do not focus on the details of an object but approach the object as a whole. Therefore, they tend to look at the big picture and get a general idea, paying little attention to detail. Individuals who have a holistic thinking style know the relationships between objects without focusing on details (Atasoy & Konyalıhatipoğlu, 2019). Students will be categorized as holistic thinkers if they prefer to comprehend mathematical information and connections as well as having unique internal and externalized pictorial imaginations and representations (Huincahue, Borromeo-Ferri, Reyes-Santander & Garrido-Véliz, 2021).

2.12 Relationship of Thinking Style in Mathematics Problem-Solving Skills.

Rahman and Ahmar's (2016) investigation of primary school students' thinking levels in relation to the process of solving mathematical problems shows that the students' problem-solving skills influences their method of thinking style on how they solve mathematical problems. Rather than indicating how a person's mathematical comprehension is evaluated, mathematical thinking styles describe how people choose to learn mathematics. Furthermore, it also reveals the person's preferred method of approaching the mathematical task (Sternberg, 1997).

Rahmy, Usodo, and Slamet (2019) conducted a study on the mathematical proficiency of 32 junior high school students based on their thinking style. The result claimed that different thinking styles have different abilities in Mathematics which then helps the educator to identify the issue faced by the students and able to provide proper treatment. Research on Mathematical skills on concrete and abstract sequential thinking styles by Utami, Pramudya, and Slamet (2020) further supports this assertion. The study's findings showed that, in comparison to sequential thinkers, students who have abstract thinking skills in Mathematical language able to solve problems. This shows thinking style can influence Mathematical problem-solving skills. Isyrofinnisak, Kusmayadi, & Fitriana (2020) concluded in their research that, Mathematical creativity in problem-solving is influenced by thinking style. This conclusion was made upon research conducted among 25 junior high school students. In this study, mathematical problem-solving skills was tested among two different thinking style students, which is holistic and analytic.

Table 2.4

Summary of Relationship of thinking style in Mathematics problem-solving skills

Title	Author	Sample	Findings
Exploration of mathematics problem solving process based on the thinking level of students in junior high school	Rahman and Ahmar (2016)	Junior high school	Students' problem-solving level affects Mathematics problem solving are based on their thinking style
Mathematics communication skill of student in junior high school based on students thinking style	Rahmy, Usodo & Slamet (2019)	Junior high school	Different thinking styles have different abilities in Mathematics which then helps the educator to identify the issue faced by the students and able to provide proper treatment
Students' Mathematical Communication Skills in Terms of Concrete and Abstract Sequential	Utami, Pramudya & Slamet (2020)	Senior high school	The result reflect that thinking style can influence Mathematical problem-solving skills
Mathematics creativity skill of student in junior high school based on students thinking style	Isyrofinnisak, Kusmayadi, & Fitriana (2020)	Junior high school	Mathematical creativity in problem-solving is influenced by thinking style

2.13 Relationship of thinking style and perceived motivation

Research by Yagci, (2016), indicated that that thinking styles do affect perceived motivation. A study conducted by Varisoglu, (2018) on 51 students claimed that thinking style affects the motivational dimension as a motivational sub-dimension of the students based on the thinking styles.

Mahmoudi, Javadi & Sahraee, (2013) carried out a study on the relationship between personality types, thinking styles, and accomplishment motivation in students attending guidance schools. The study was conducted among 400 students and the result revealed that there is a positive correlation between the judicial and executive similar to analytics subscales of thinking styles and achievement of motivation, whereas the subscales measuring legislative style and achievement motivation did not significantly correlate..

In addition to that, Nakhaei, Amiri Majd, Mohamadi Arya, & Shiraz (2018) conducted a study among 368 students on the relationship between student motivation and teacher teaching style which effected by students thinking style. The findings demonstrated that, as a result of learning mediator, thinking style have a direct and substantial impact on students' motivation. Furthermore, research on high-order thinking skills HOTS-based assessments in terms of conceptual understanding, digital literacy, motivation, divergent thinking, and creativity by Widana, Sumandya, Sukendra, & Sudiarsa (2020) claimed that motivation had a direct positive effect on students, indicating that thinking style may have an impact on motivation.

Hence, this study also investigated the influence of thinking styles on perceived motivation.

2.14 Theoretical Framework

The design and development of the instructional materials was theoretically based and pedagogically addressed to provide relevant instructional materials. Therefore, established and resourceful instructional designs and theoretical frameworks was applied to produce effective instructional materials. This study was grounded with

four main instructional design models and theories as outlines to design and develop the MGBL application.

In this study, the MGBL application was designed and developed based on the ADDIE model, Churchill, King & Fox (2013), Resources, Activity, Support, and evaluation (RASE) Pedagogical Model for Integrating Technology, and Keller's ARCS Model of Motivational Design (1987).

ADDIE model was used as a framework for the development of the MGBL application. Churchill, King & Fox RASE Pedagogical Model for Integrating Technology was used as a guide for developing the MGBL intervention in terms of subject content structure on problem-solving skills, whereas Keller's ARCS Model of Motivational Design (1987) provides the guidelines for the development of MGBL application on the motivational aspect. Figure 2.2 illustrate the theoretical framework of this study.

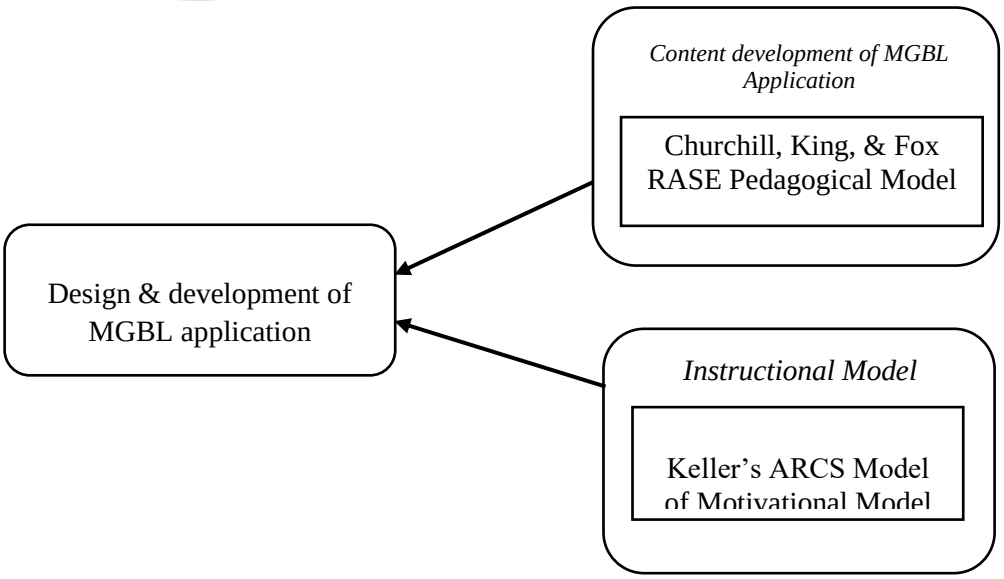


Figure 2.2. Theoretical Framework of the research

2.14.1 ADDIE Model

Figure 2.3 shows the five-phase ADDIE model.

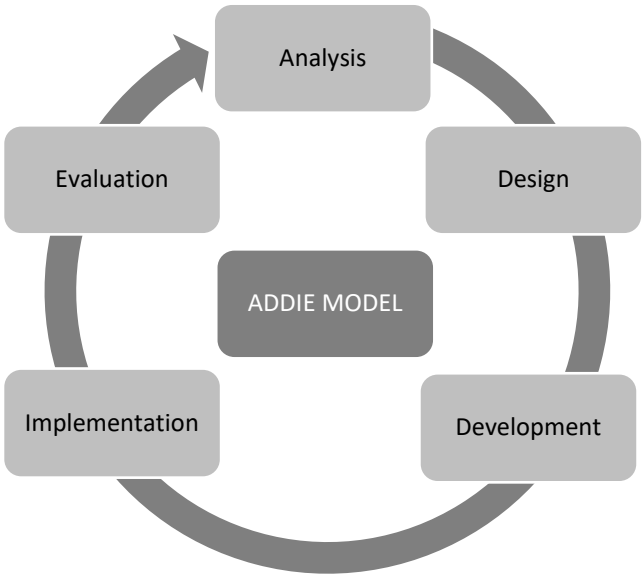


Figure 2.3. ADDIE MODEL

ADDIE instructional design model, which was invented by Florida State University (1975) is a model of systematic learning design. This methodology is based on the theoretical framework of learning design and was developed methodically. This model is organized and programmed with steps of methodical actions to address learning challenges pertaining to educational materials that align with the requirements and attributes of learners. This model consists of 5 phases, namely analyze, design, development, implementation, and evaluation (Widyastuti, 2019).

The Analysis phase can be considered as the "Goal-Setting Phase." This phase involved the clarification of instructional challenges, the establishment of instructional goals and objectives, the identification of the learning environment, the knowledge and skills already had by the learners, and the collection and gathering of requirements for the development. In the next phase, the idea was translated into a

draft form, in terms of content creation, development of storyboards, and identification of multimedia elements for the instructional model. In the development phase, the content was developed based on the multimedia elements using suitable software and followed by the implementation phase, where the material was implemented to the target audience. Finally, in the evaluation phase, formative and summative evaluations was performed among the respondents.

Table 2.5 shows the summary of relevant research and development of Mobile Game-Based Learning Applications by using the ADDIE model.

Table 2.5

Summary of relevant research and development of MGBL application

No	Researcher/Year	MGBL Application	Level
1	Samur, Y. (2019)	A mobile game designed to improve kindergarteners' recognition of letter sounds	Pre-school
2	Shukri, M. R. M., & Ariffin, S. A. (2019).	Process of Awang Sains 2D Digital Mobile Game	Primary
3	Handican, R., & Setyaningrum, W. (2021)	Mobile Game Using Scientific Approach to Support Mathematics Learning	Junior High school
4	Elmunsyah, H., Kusumo, G. R., Pujianto, U., & Prasetya, D. D. (2018, October)	Mobile Based Educational Game as a Learning Media for Basic Programming in VHS	High school

2.14.2 Churchill, King, & Fox RASE Pedagogical Model

Resources, Activity, Support, and Evaluation is the name of the pedagogical student-centered learning paradigm that is being employed (RASE). Churchill, King, and Fox created the RASE model in 2013. This MGBL application was designed using the

RASE model because it was established on a variety of theoretical concepts, problem-solving techniques (Jonassen, 2000), engaged learning (Dwyer, Ringstaff & Sandholtz, 1985-1998), problem-based learning (Savery & Duffy, 1995), rich environments for active learning (Grabinger, 1996), technology-based learning environments (Vosniadou, 1995), interactive learning environments (Harper &Hedberg, 1997; Oliver 1999), and more.

The RASE model consists of four major elements: Resource, Activity, Support, and Evaluation. This model is illustrated as shown in Figure 2.4.

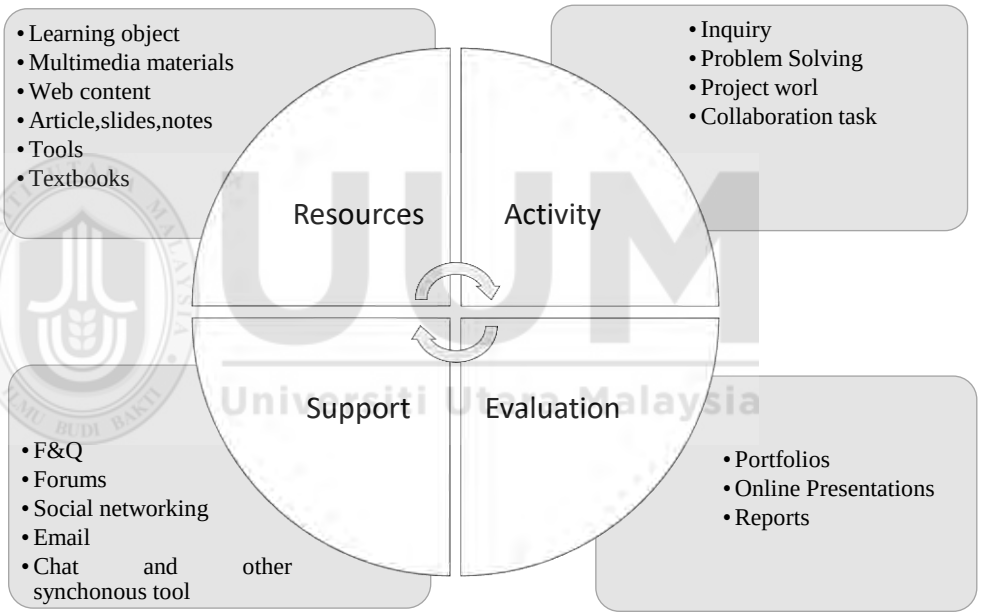


Figure 2.4. RASE Model

In this study, the RASE model were used as a foundation to achieve the intended learning outcome in terms of problem-solving skills and because it is that the pedagogical model developed for a student-centered and authentic curriculum. The main focus of the RASE model is on how best to use or integrate the technology to

boost student learning and satisfaction (Churchill, King & Fox, 2013; Churchill, King, Webster & Fox, 2013).

The four constructs in the pedagogical model indicated in collaboration with MGBL application as below table:

Table 2.6

Collaboration of Pedagogical model with MGBL application

Construct	**Elements in the application**	**Explanation**
Resources	Content & Tools	The content was developed to engage students in Mathematics learning. It includes. Content: Year 4 Mathematics textbook, exercise book, professional teacher handouts, and exam question. Tools: Android application and online application.
Activity	Question	Learning experience using resources (MGBL). Mathematics questions was the main learning activity. These activities are learning experiences where students can improve and learn on understanding, test ideas and apply knowledge in terms of problem-solving skills and more. Good learning activities able students to develop their learning and achieve learning outcomes.
Support	Tutorial Video	In MGBL, the support was in the state of student-learning resource where it was provided with some video tutorials which lead to self-learning. Moreover, students were able to improve their perceived motivation towards the MBGL application. This is because there was support for them to perform the main activity.
Evaluation	Scores and reward	This MGBL application provided a captivating method of evaluation in terms of scores rewards and more.

2.14.3 Keller's ARCS Model of Motivational Model

The ARCS Motivational Development Model (1987) was able to provide instructional content to provide efficient and motivational materials for the instructional materials. The ARCS model was created in order to find a more efficient method of understanding the primary factors influencing learning motivation as well as a methodical approach to recognizing and resolving issues related to learning motivation (Keller, 1987). The macro theory of motivation and instructional design created by Keller (1979, 1983, 1987a: Keller & Kopp, 1987) forms the basis of the ARCS model. The model comprises four major dimensions: attention (A), relevance (R), confidence (C), and satisfaction (S) as indicated in figure 2.5. The principles that being explained by this dimension are described in the Table 2.7

Figure 2.5. Keller's ARCS Model of Motivational Model

Table 2.7

Principles of each dimension

Conditions	Principles
Attention	Motivation to learn is promoted when a learner's curiosity is aroused due to a perceived gap in current knowledge
Relevance	Motivation to learn is promoted when the knowledge to be learned is perceived to be meaningfully related to a learner's needs and goals.
Confidence	Motivation to learn is promoted when learners believe they can succeed in mastering the learning task.
Satisfaction	Motivation to learn is promoted when learners anticipate and experience satisfying outcomes to a learning task.

The four major dimension of the ARCS model was implemented in the development of the MGBL application for students to perceive motivation in using this application.

Table 2.8 describe how the dimensions were integrated into the design and development of the MGBL application in this study.

Table 2.8

Integration of dimension into MGBL

Dimension	Elements in the application	Description
Attention	Tutorial Video	MGBL application allowed users to refer to the tutorial video while solving the question which helped to improve self-learning.
Relevance	Multimedia elements	This MGBL application contribute a fun learning experience as expected by young learners.
Confidence	Levels	Unlocking each level motivated and make them believe that they have

		learned and achieved on the specific topics.
Satisfaction	Scores and reward	The score for each question, level, and final reward gave them satisfaction feel where they believed that they have learned and revised the mathematics subject.

2.15 Research Framework

The goal of this study was to examine the effect of MGBL application on mathematical problem-solving skills and perceived motivation among different thinking style of Year 4 primary students. The independent variable is MGBL application, which was designed and developed based on Churchill, King, & Fox RASE Pedagogical Model for content and Keller's ARCS Model of Motivational Model as instructional model to supports the motivational aspect of MGBL application The dependent variables for this study are: (i) problem solving skill, (ii) perceived motivation. Problem solving skill was measured by pre-test and post-test and perceived motivation by Instructional Multimedia Motivation Scale (IMMS) (Keller, 2001). Thinking style i.e. logical and analytical was used as the moderator variable.

The research framework of a study is illustrated as in Figure 2.6

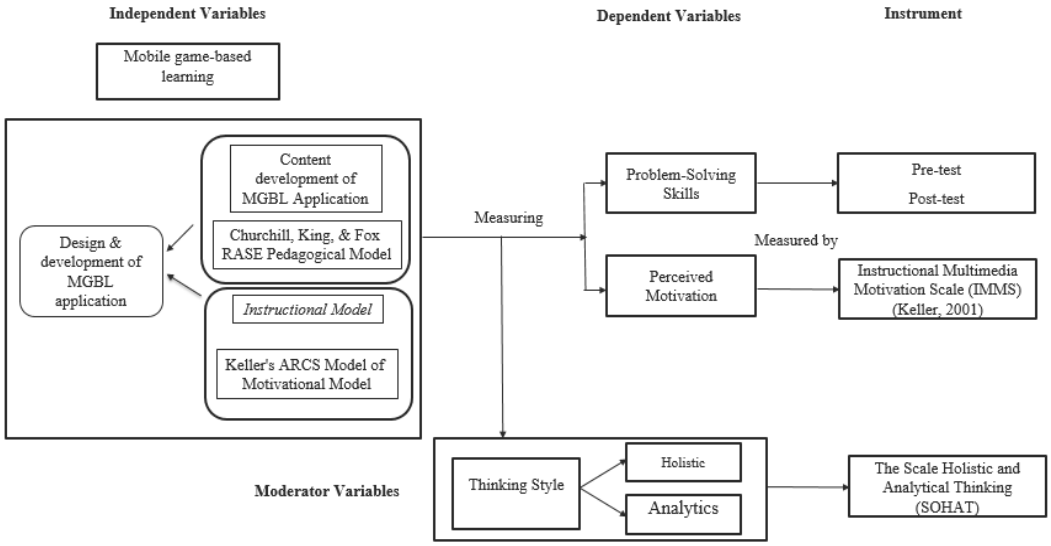


Figure 2.6. Research Framework

The overall idea of ROMAAD was based on Churchill, King, & Fox RASE Pedagogical Model which emphasizes on integrating the technology to boost student learning on problem-solving skills and satisfaction (Churchill, King & Fox, 2013; Churchill, King, Webster & Fox, 2013) as this treatment were designed to improved Mathematical problem solving skills. Keller's ARCS Model of Motivational Design supports the motivational aspect and instructional content structure of ROMAAD. Problem-solving skills were examined by pre and post-test. The Scale of Holistic and Analytical Thinking (SOHAT) was used to examine the impacts of thinking as the moderator variable in this study, while the Instructional Multimedia Motivational Scale was used to measure perceived motivation.

2.16 Summary

This chapter provides an overview of GBL, the importance of Mathematics learning, Mathematics problem-solving skills, perceived motivation thinking styles, and MGBL application. This chapter also presents a review of the theoretical framework which

can classify as the foundation of this study. Based on the previous studies it is also helpful to identify existing issues in Mathematics problem solving and able to figure out components that was included in MGBL, for Mathematics problem-solving skills motivation. Finally, the MGBL application was developed based on the theoretical framework that involves ADDIE model for the development process, RASE Pedagogical Model for the content creation requirement of MGBL, and Keller's ARCS Model as an instructional model.

CHAPTER 3

METHODOLOGY

3.1 Overview

The purpose of this study was to determine out how well two type of thinking style Year 4 primary students' Mathematical problem-solving skills and perceived motivation were enhanced by a mobile game-based learning (MGBL) application.

This chapter discussed the variables, research tools, samples and sampling technique, and study design. Additionally, the data analysis methodology and data collection techniques were discussed in this chapter. The details of designing instructional materials, the processes of data gathering, and statistical analysis also was included.

3.2 Sample and Population

According to Murphy (2016), the research population referred to the total subjects that the researcher wants to retrieve information and to state a conclusion. The process of selecting a sample for a study involves going through the entire set of cases, or the population, as defined by Taherdoost (2016). The sample size is the number of subjects involved in the research on which the experiment was conducted (Aron & Aron, 2009). For this research, the whole total population of Year 4 students in Malaysia is 455,922 (Ministry of Education, 2021). From this population, a sample of 314 students has been selected as respondents of this research who was conveniently chosen from six national primary schools which is four Sekolah Kebangsaan (SK) with dual language, and two Sekolah Jenis Kebangsaan Tamil (SJKT). Using the sample size chart from Krejcie and Morgan (1970), the sample size (n=314) was determined with a 5% margin of error. Purposive sampling was applied in this

research as it is a method access respondent who possess specific knowledge, experiences, or characteristics relevant to the research topic (Nyimbili, 2024). The sample was consisting of respondents who are homogeneous in terms of their technology exposure and from schools within a similar geographical area which is urban. This is because respondents from the urban area are the ones who have more technology exposure and implement dual-language mathematics subjects in schools than in rural areas. The sample subject was Malaysia's Year 4 School students.

The samples were taken from 6 primary schools and was divided into two (2) groups. The students from three (3) schools were participated as respondents for the control group whereas students from another three (3) schools became the respondents for the experimental group. This is to restrict any interaction between the respondents to avoid internal validity threats.

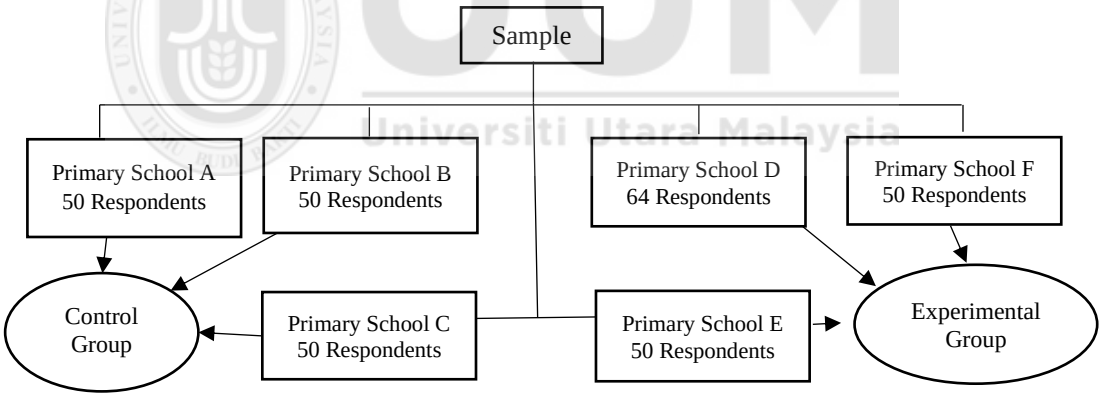


Figure 3.1. Summary of sampling method

3.3 Research Design

Quasi-experimental was employed in this research. This research design is selected because the aims of this research was to investigate the effect of a mobile game-based learning (MGBL)

Application as an independent variable on two dependent variables which are problem-solving skills and perceived motivation. This research also measured thinking styles namely holistic and analytical as moderator variables.

Selected subjects were categorized into two groups, the control group who learned via the existing method which is using courseware which has been implemented since 1998, and the experimental group who used the MGBL intervention to measure the dependent variables. In this study, there was one independent variable, two dependent variables, and moderator variable with two dimensions. Therefore, it employed 1x2 factorial design. The independent variable was the mobile game-based learning application whereas else the dependent variables are the Mathematical problem-solving skills and perceived motivation. It was also designed to measure the moderator variable, which is the thinking styles, analytics and holistic on the dependent variable for both groups. This study specifies the chosen subjects conveniently to experimental groups (X) to measure the dependent variables (O) concerning moderator variables. Table 3.1 shows the factorial design for the study with factors X and O.

Table 3.1

Factorial design of the research

Independent Variable	Moderator Variable (TS)		Dependent Variables
Mobile Game-Based Learning Application	LT	AT	O_1 O_2

O_1 Problem Solving Skills

O_2 Perceived Motivation

LT Holistic-thinking

AT Analytical –thinking

TS Thinking style

The researcher used three experimental groups and three control groups as respondents:

i. The experimental group (consisted of HT and AT respondents who will be using the MGBL application.

ii. Control group (consisted of HT and AT respondents who will remain with the existing learning method.

The research design with and without the intervention which is by using MGBL application and existing method and instruments involved are illustrated in figure 3.2.

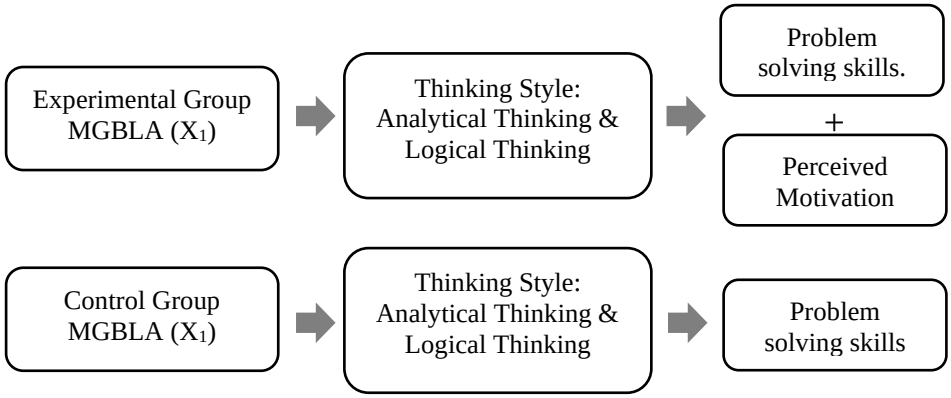
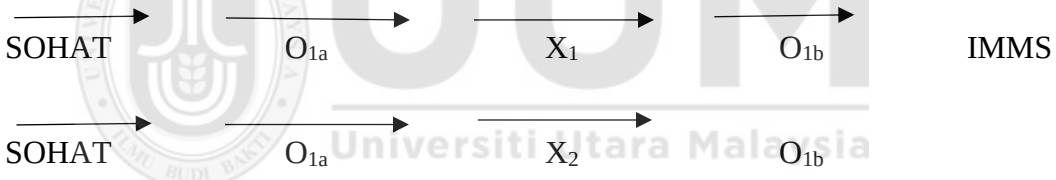


Figure 3.2. Research Design

The research experiment was carried out with prearranged selected classes under the researcher and teacher supervision. Prior to the intervention, respondents thinking styles will be analysed using The Scale of Holistic and Analytics Thinking (SOHAT) and classified in both groups. Then pre-test questions were given to both groups of respondents. Then the intervention was given only to respondents under the experimental group, respondents experienced it individually and, in the class, as per their convenience. Respondents under the control group was practicing and learning the same content via the existing method. After two weeks of learning the content, a set of post-test questions was answered by both groups' respondents. The result from both groups of respondents was recorded. After the post-test respondents perceived motivation of the instructional also was measured using Instructional Materials Motivation Scale (IMMS).



$O_{1a:}$ Pre test $X_{1:}$ MGBL Application (Experimental group)

$O_{1b:}$ Post test $X_{2:}$ Existing learning Method (Control group)

Figure 3.3. Quasi- experimental Pre-test and Post-test design

3.4 Intervention Material

The respondents under the experimental group were assigned to the MGBL application and the respondents under control groups followed the existing method used in school. The intervention material which is the MGBL application was developed based on the Malaysia Year 4 Mathematics syllabus which consists of a total of 18 chapters. This application consists of 18 levels which represent each

chapter. Tutorial videos for addition, subtraction, multiplication, and division also included in this application for the students to refresh their knowledge. Moreover, game elements that incorporated in this MGBL application such as storyline, characters, obstacles, and rewards which increased the interest of students and made them engage in the learning content. It also contains exercises & feedback so that the respondents will have a better understanding and help to improve their problem-solving skills.

Besides that, the MBGL application provided an interactive learning environment and also aids self-learning anywhere anytime. It was developed with the concept of every level was designed with different backgrounds according to a different theme. After they complete each level, players can choose from a variety of game level. Features and elements that used to design and develop the intervention was able to contribute to perceived motivation towards Mathematics subject whereas for Year 4 students are still young and love to learn in fun ways.

The specification treatment material of the MGBL application are listed in the following Table 3.2

Table 3.2

MGBL application intervention material specification

Characteristic	**Mobile Game Application**	
Variables	Mobile Game-Based Learning Application	
Goals	1. Provided a new platform to practice Mathematics to Improve Mathematics problem-solving skills and perceived motivation with the influence of thinking style. 2. To increase the motivational level to learn Mathematics through this fun learning method.	
System	Operating system	Android

	Language	English
Elements	Text	√
	Graphic	√
	Video	√
	Animation	√
	Audio	√
Features	Tutorial	√
	Assessment	√
	Feedback	√
	Score	√
	Reward	√

3.4.1 Design & development of the MGBL application

The MGBL application that functioned as the intervention material was designed and developed based on the ADDIE model (Figure 3.2). ADDIE model was employed as the framework to guide the generic processes of designing and developing the intervention material. ADDIE model represents a guideline for developing the MGBL application in five phases; Analysis, Design, Development, Implementation, and Evaluation. The next subsection describes the design and development process. And table 3.3 describes each phase and its outcome.

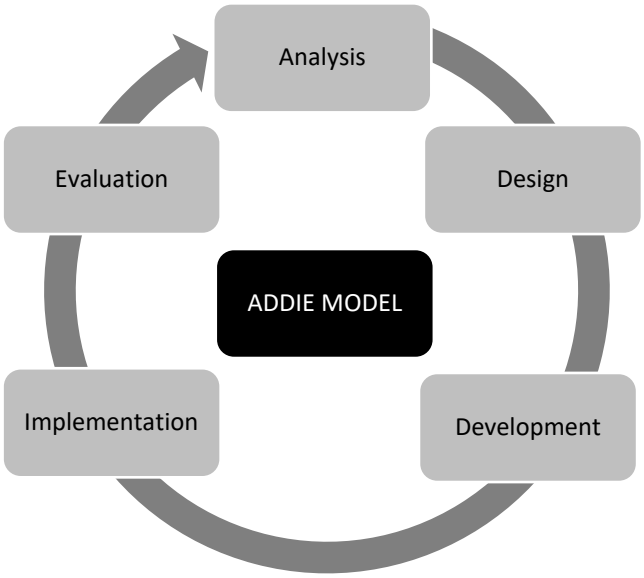


Figure 3.4. ADDIE Model

Analysis and requirement is be the first step in the ADDIE model. In this phase, analysis about similar applications and the mobile game was carried out while collecting all the possible information from the existing game for the content. In this phase, the problem faced by Year 4 students in Mathematics subject was identified. The developers identified the requirement and the components for the design and development of the mathematics based game. The output for this phase was the requirement plan for the analysis.

In design stage, the developer designed the look and content of the MGBL application. A storyboard was developed as a guideline for the interface of the MGBL application. Then, the researcher developed a medium-fidelity prototype as the visual representation to illustrate the mobile game interface and navigation. This stage determined how suitable the interface of the application will be. This ensured that the intervention is user-friendly and understandable. Other elements such as animation, text, audio, graphics, and sound effects details was also considered to attract the respondents. Despite the design on the interface the design of the content was also done with adaption of integration of Computational Thinking (CT) model and GBL elements to enhance students' mathematical problem-solving skills. The design on the integration is as below figure 3.5 & 3.6

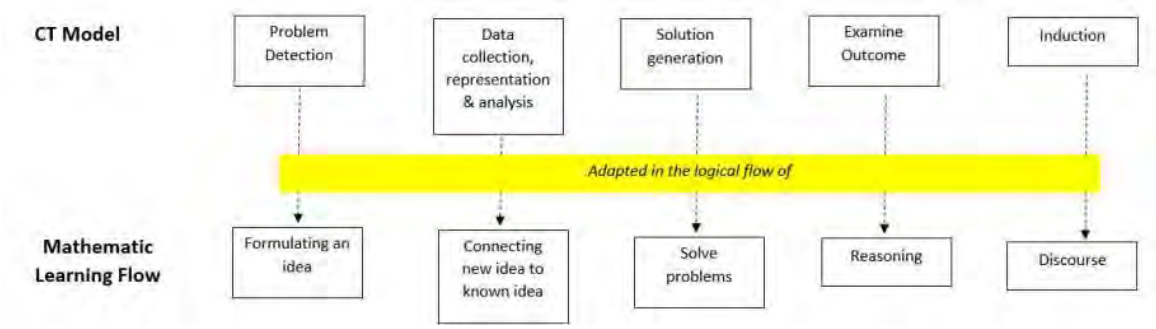


Figure 3.5 GBL construct is adapted in each step of the mathematical learning flow

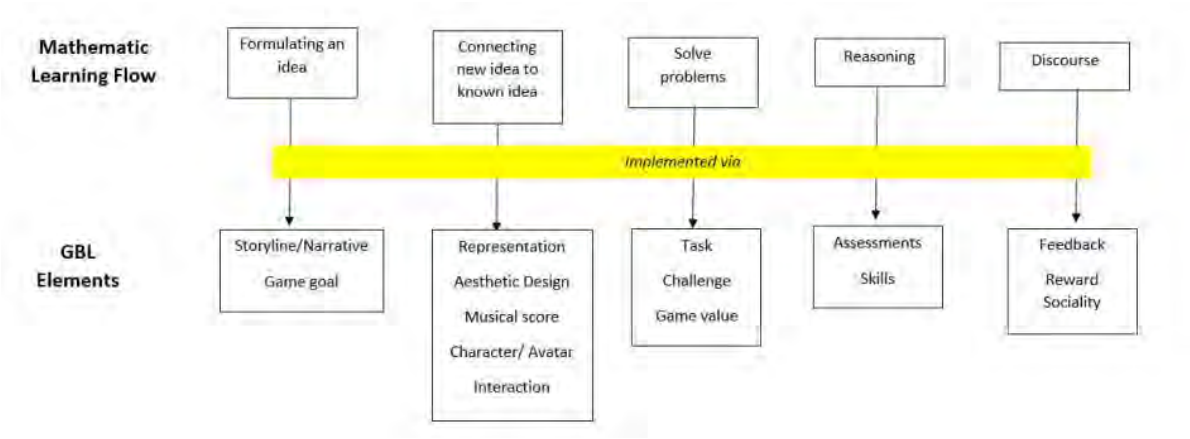


Figure 3.6. Integration of GBL elements in the Mathematical Learning Flow

In the development phase, the components of the game were developed using the Unity Real-Time Development Platform. It used as the authoring tool to assemble all the elements. Software such as Adobe Photoshop and Adobe Illustrator also was used for the graphic design. Audacity was used to produce and record the sound and narration. The tutorial videos produced using Adobe after Effect and Adobe Premiere Pro. In addition to that, a user manual also was developed, so that users can understand the intervention. The output for this phase is a high-fidelity prototype.

During implementation, the developed high-fidelity prototype was implemented in the Mathematical learning of Year 4 students as a pilot study. The respondents were chosen conveniently among national primary schools. The respondents experienced the application to identify the errors and navigation. Moreover that, but the prototype was also given to the content expert and user interface experts to be reviewed.

The last phase is the evaluation process. In this phase, the MGBL application evaluated for its user interface and usability by the content expert, user interface expert, and users. The experts evaluated from the aspects of content and user interface where else the respondents evaluated from the usability aspects. The researcher

improved the performance, interface, and usability aspects according to the feedback received from the experts and the respondents on the interface, navigation, and usability. Detailed design and development process explained in chapter 4.

Table 3.3

Process and outcome of design and development of the MGBL application

Phase	Description	Outcome
Analysis	Gaps from the existing application will be identified to come out with relevant components for the development of the MGBL application	Requirement plan for the MGBL application.
Design	Based on analysis contents, ideas, flow, and the component of the application will be determined.	• Storyboard • Medium-fidelity prototype
Development	Referring to the output of the design phase, the application will be developed.	High-fidelity prototype
Implementation	The pilot study was conducted among Year 4 students. The respondent experienced the application. Content expert, the user interface reviewed the application.	Review and feedback to improve the performance, interface, and usability.
Evaluation	Evaluation was done by the respondent, and experts from the aspects of the content, interface, and its usability.	

3.5 Research variables

3 types of variables were employed in this study, independent variables, dependant variable, and moderator variable. These summarized variables were illustrated in Figure 3.4. The next subsection explains the variables in detail.

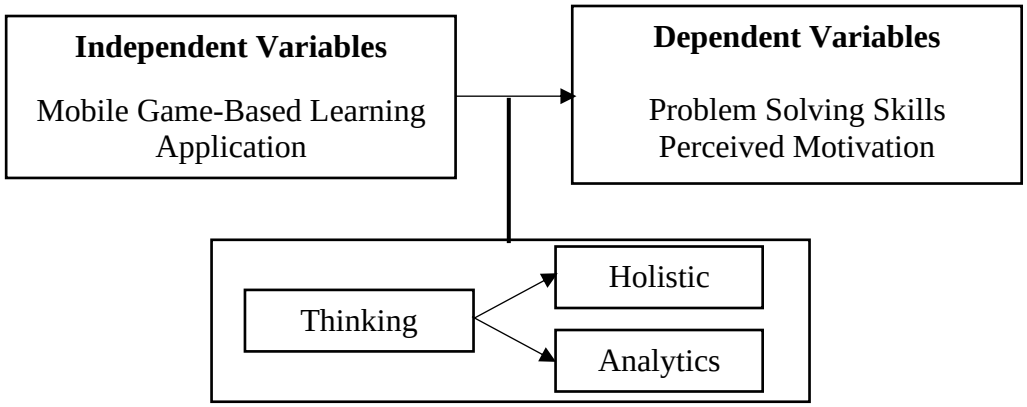


Figure 3.7 Relationship between Variables

3.5.1 Independent Variables

The independent variable was the mobile game-based learning application that participants in the experimental group utilized. This interactive teaching technique for Year 4 Mathematics was utilized in Malaysia through the usage of an educational mobile application. It covered all the Year 4 Mathematics syllabus with an appealing and well-designed interface to encourage students to learn mathematics and to add enjoyment and satisfaction to the learning process. Additionally, this program helped students become more proficient at solving mathematical problems. They also became better at responding to questions quickly and retained the process for doing so.

3.5.2 Dependant variables

There are two dependent variables involved in this research: Mathematical problem-solving skills and perceived motivation.

Mathematics problem solving: Problem-solving skills generally refers to the ability to cope with difficulties and it is the ability to spot and solve problems by applying skills thoroughly with various thinking ability (Nezu & Nezu, 2016). Mathematics emphasized that problem-solving skills need to be improved in order to achieve in Mathematics (Darmawan & Suparman, 2019). Students' Mathematical problem-solving skills was evaluated and measured using pre-test and post-test which was applied twice: before and after the learning intervention and learning process.

Perceived motivation: Nikou and Economides (2016) define perceived motivation as "the process whereby goal-directed activity is encouraged and sustained. The Instructional Material Motivational Scale (IMMS) (Keller,1993) was used to access the level of perceived motivation of the instructional material. This tool applied after the intervention.

3.5.3 Moderator Variables

There was one moderator variable which is the respondent's thinking style. Thinking style refers to the way of thinking during the process of gaining knowledge or solving a problem (Rani & Agarwal 2020). This thinking style divided into two, holistic and analytics.

A person with an analytical thinking style will have the ability to solve a problem based on knowledge and idea of certain topics which allows to break down complex problems into single and manageable smaller components to have good decision

making (Kayali & Yilmaz, 2017). An individual who has holistic thinking does not focus on the parts of the object but approaches the object (Atasoy and Konyalıhatipoğlu, 2019). This variable is required to identify the thinking styles of respondents that are used for their problem-solving skills. This will be assessed by using The Scale of holistic and analytical thinking" (SOHAT) which was developed by Umay and Arıol (2011). The lowest score is 5 and the highest score is 15. Analytical thinking will be determined based on score 5-8 where else holistic thinking will be determined based on score 9-15.

3.6 Research Instrument

Three instruments was used to measure the effectiveness of mobile game-based learning application on the student's problem-solving skills and perceived motivation namely pre-test and post-test Mathematics questions, Instructional Multimedia Motivation Scale (IMMS (Keller, 2001) questionnaire was used and The Scale of Holistic and Analytical Thinking" (SOHAT) was used to determine the moderator variable which is the student's thinking styles whether the students are analytical thinkers or holistic thinkers. The pre-test and post-test was used to measure the student's mathematical problem-solving skills. It was valid and reliable as it will obtain from school and the questions was developed and validated by professional Mathematics teachers. Where else to measure students' perceived motivation level the IMMS (Keller, 1993) questionnaire was used.

Table 3.4

Summary of Research Instruments

Test	Developer/Year	Type	Questions /Item	Description
Pre-test & Post-test (Mathematics Question)	Mathematics teacher (MOE)	Problem-Solving skills	40	Consist of Year 4 Mathematics problem-solving question
Instructional Materials Motivation Scale (IMMS)	Keller (1991)	Perceive motivation	36	Measure four dimension • Attention • Relevance • Confidence • Satisfaction
The Scale Holistic and Analytical Thinking	Umay & Ariol (2011)	Thinking style	5	Holistic and Analytics thinking

3.6.1 Pre-test and Post-test questions

A set of Year 4 Mathematics questions was used during the pre-test and post-test. Although it was similar in both of the tests, the questions was randomly structured. This set of questions was obtained from the Ministry of Education so that the question will be valid as it was developed and validated by the experts who are professional Mathematics teachers and it was based on the format of the examination questions. This set of questions covered all the 18 chapters in the Year 4 syllabus which consist of total 35 questions.

3.6.2 Instructional Material Motivational Scale (IMMS)

The Instructional Material Motivational Scale (IMMS) (Keller, 1991) was applied to measure students' perceived motivation for the instructional material. IMMS was

developed for measuring responses to self-directed instructional materials (Keller, 2010). This instrument has been used by many researchers that conducted research involving perceived motivation. In a study conducted by Chin, Yahaya, & Muniandy (2018), IMMS from Keller was employed to identify students'perceived motivation. Even Annamalai (2016) determined perceived motivation towards the new learning material among Polytechnic students by using the Instructional Materials Motivation Survey (IMMS). The Likert-style scale instrument has 36 items four (4) subscales which are attention, relevance, confidence, and satisfaction. Nine items are listed under Relevance and Confidence subscales respectively, the Satisfaction subscale has six-item, and the Attention subscales consist of 12 items. The scales value for each statement is: (a) 1 – not true, (b) 2 – slightly true, (c) 3 – moderately true, (d) 4 – mostly true and (e) 5 – very true. The reliability coefficient based on Cronbach's alpha was satisfactory at 0.96 (Keller,2010). As for the attention, relevance, confidence, and satisfaction scored more than 0.7 indicating that the items can be used for the evaluation purpose.

A summary of Cronbach's Alpha reliability coefficient by Keller,2010 for each IMMS factor is as shown in Table 3.5.

Table 3.5

Cronbach's Alpha reliability coefficient

ARCS Elements	Items	Cronbach's Alpha Coefficient (Keller, 2010)
Attention	12	0.89
Relevance	9	0.81
Confidence	9	0.80
Satisfaction	6	0.92

Total	36	0.96

Table 3.6 Shows the ARCS element category for the IMMS questionnaire.

Table 3.6

ARCS element category for the IMMS questionnaire

ARCS Elements	Strategy Components	Item Number
Attention	Strategies for arousing and Sustaining curiosity and interest	2, 8, 11, 12*, 15*, 17, 20, 22*, 24, 28, 29*, 31* (12 items)
Relevance	Strategies that are linked to the learner's need, interest and motives	6, 9, 10, 16, 18, 23, 26*, 30, 33 (9 items)
Confidence	Strategies that help the students to develop positive expectations for successful achievement	1, 3*, 4, 7*, 13, 19*, 25, 34*, 35 (9 items)
Satisfaction	Strategies that provide extrinsic and intrinsic reinforcement for effort	5, 14, 21, 27, 32, 36 (6 items)

(* indicates reverse statements)

Source: Keller (2010)

3.6.3 The Scale of Holistic and Analytical Thinking (SOHAT)

The Scale of Holistic and Analytical Thinking (SOHAT) tool developed by Umay and Arıol (2009) was used to determine the respondents' thinking styles. This tool was used among Year 4 primary students as the instrument has already been used in various research involving middle school children (Atasoy & Konyalıhatipoğlu, 2019). The elements that form this instrument are based on the characteristics of holistic and analytical thinking styles in literature and are believed to represent the impact of these styles on problem-solving skills. There are five (5) items on the scale and these items are intended to indicate whether students are closer to analytical or

holistic thinking. Each item has a problem-solving expression that fits a style of analytical and holistic thinking in which individuals able to express their preferences in problem-solving situations. The reliability coefficients were calculated, and the scale is finalized (Arıol, 2009). The outcome of the reliability coefficient of the scale is 0.78. The result of this scale will determine that the students are closer to the analytical or holistic thinking style. On this scale, a minimum of 1 and a maximum of 3 points could be received from each item. Therefore, for the five items, a minimum score of five and a maximum score of 15 could be achieved. Those with a holistic thinking style will receive a maximum of 15 points from the entire scale while those with an analytical thinking style will receive a maximum of 5 points. As a student gets closer to the score of 5, they seem to be closer to the analytical thinking style. If the student's score is closer to 15, they tend to be with a holistic thinking style. Table 3.6. Show summary of score calculation.

Table 3.7

Thinking style score calculation

Thinking Style	Students with an analytical thinking style							Students with a holistic thinking style						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Source: Umay & Ariol, (2009)

3.7 Overall Research Procedure

In this research, five main steps was implemented; (i) identify research subject (ii) design and development of instructional materials of MGBL application (iii) validity and reliability of research instruments (iv) conduct of research, and (v) data collection and analyses.

(*i) Identify Research Subjects*

The first step is known as the specific information required to achieve the intended learning outcome. The objective of this research was to improve Mathematics problem-solving skills and perceived motivation towards Year 4 Mathematics subject. The content of this MGBL application was based on Year 4 Mathematics syllabus. A sample of 314 students was selected conveniently from six primary schools as respondents. These students are similar and homogeneous in terms of their technology exposure and from schools within similar geographical areas i.e urban.

(ii) Design and Development of Mobile Game-Based Learning Application

The design and development of the MGBL application are based on the ADDIE model. Firstly, Analysis was carried out about similar applications. The problem faced by Year 4 students in Mathematics subject also was identified.

At this point, the researcher has identified the requirement and the components for the design and development of the MGBL application. The researcher has gathered data using face-to-face interview technique with a subject matter expert and questionnaire is answered by 35 Mathematics teachers. The result of the interview and questionnaire was used to determine the functional and non-functional requirements of the MGBL application during the development phase. The functional requirements are select

menu, play game, manage the setting, exit, and the non-functional requirements are user interface, usability, compatibility, availability, maintainability, and performance.

Based on the requirements obtained, the researcher then began the design and development process. The MGBL application went through alpha and beta testing to identify errors. Alpha study was carried with content experts on the MGBL content and user interface experts. Any feedback from the alpha study on improvement was revised and proceed to the next phase of testing which is the beta test among the students. The intervention again was further revised and evaluated to identify improvement and bugs in a smaller sample of intended students who are not involved in the alpha pilot study. The findings from the testing were then used for the improvement of MGBL application for learning Years 4 Mathematics. The in-depth explanation of this process is explained in Chapter 4.

(iii) Finalizing of Research Instruments

It is required for successful research that the instruments used are valid. In this research, all research instruments were tested for validity. The Pre-test and Post-Test Mathematics questions was developed and validated by subject matter experts who professional Mathematics teachers are. Where else The Scale of Solving Holistic and Analytical Thinking (SOHAT) and IMMS instruments were validated and tested for reliability by the original researchers.

(iv) Conduct of actual research

The actual research was conducted on the 314 Year 4 respondents from six national primary schools. The experimental group and the control group were the two groups into which the respondents were divided. Before the implementation of the

intervention on the respondents, students thinking style was measured by using The Scale of Holistic and Analytics Thinking (SOHAT). After that, students were given a pre-test question which is a Mathematical problem-solving question. Then the intervention was given only to respondents under the experimental group, they utilized it individually or in the class as per their convenience. Respondents under the control group practiced and learned the similar content via the existing method. After the implementation of the intervention and existing learning method, the same set of post-test questions was answered by both groups' respondents. The result from both groups was recorded. After the post-test respondent's perceived motivation on the intervention also was measured using Instructional Materials Motivation Scale (IMMS).

(v) Data Collection and Analyses

For the data collection and analysis process, three instruments will be used. The Scale of Holistic and Analytical Thinking (SOHAT) was employed for both control and experimental group respondents to identify their thinking style either they are analytical thinkers or holistic thinkers. Then the pre-test was carried out whereby the respondents was given a set of questions to answer to identify their level of Mathematical problem-solving skills. The score was recorded. Then the respondents under the experimental group experienced the MGBL intervention for two weeks while the control group respondents were learning via existing method. Then, the post-test was done using the same set of Mathematics questions used during the pre-test to measure and the researcher compared Mathematics problem-solving skills scores. The question for pre-test and post-test were reshuffled randomly to avoid validity threats. After that, the students were given Instructional Materials Motivation Scale (IMMS)

questionnaire to measure the student's perceived motivation for the instructional material. All scores and data obtained was analysed by using statistical analysis SPSS. Figure 3.5 shows the summary of the overall research procedure of this research. Detailed explanation on the result and data analyses will be explained in Chapter 5.

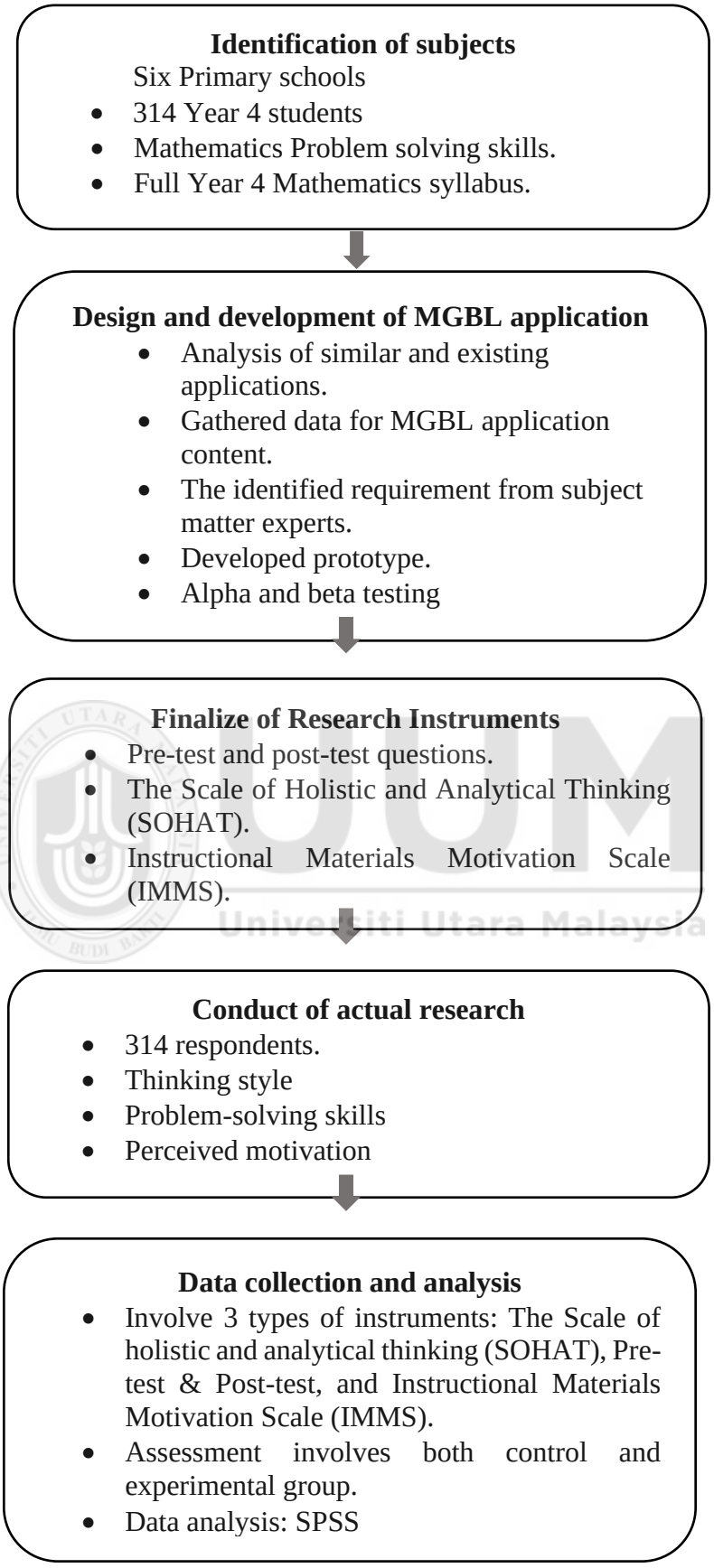


Figure 3.8. Summary of overall research procedure of this research

3.8 Procedure and Method for Data Analyses

For this research, the data collected consist of pre-test and post-test scores for problem-solving skills, IMMS scores to measure the perceived motivation of the intervention, and SOHAT scores to identify the respondent's thinking styles.

All the data that collected through this research will be compiled and analysed by using Statistical Packages for Social Science (SPSS). The analyses employed statistical analyses based on the generated research question. It was parametrically analysed which are a descriptive statistic, paired t-Test, and Analysis of Covariance (ANCOVA). The type of data analysis method for each research analysis is shown below the table.

Table 3.8

Type of data analysis method for Research Hypotheses

H	Hypotheses	Type of Analysis	Reason
H_{03}	There is no effect of MGBL application on the improvement of students' mathematical problem-solving skills.	ANOVA	It investigates effect of one independent variable (ROMAAD) on two dependent variable within two different groups.
H_{04}	There is no significant interaction of the students' thinking styles on the use of ROMAAD application to improve students' problem-solving skills.	Descriptive Statistic	The descriptive statistic was calculated due to the dependent variable was only investigated within one group as there was no comparison within two or more groups
H_{05}	There is no effect of using ROMAAD application on the students' perceived motivation for the instructional material.	Paired t-Test	Paired t-Test was used as to test whether the mean difference between pairs (Thinking style) of measurements is zero or not.
H_{06}	There is no significant interaction of the students thinking style on	Paired t-Test	Paired t-Test was used as to test whether the mean difference between pairs

	the use of MGBL application on students' perceived motivation.	(Thinking style) of measurements is zero or not.

3.9 Summary of the chapter

This chapter explained how this research was conducted as it presents the methodology, procedures, sample, sampling method, and instruments. The purposive sampling method was applied in this research. One by two (1 X 2) quasi-experimental designs were used in this research to establish the effectiveness of MGBL application in terms of problem-solving skills and perceived motivation. Moreover, methods for data collection and analysis are also discussed in detail. The next chapter explained detailed design and development of ROMAAD.

CHAPTER 4

DESIGN AND DEVELOPMENT OF ROMAAD

4.0 Overview

The development and design of ROMAAD are explained in this chapter. It provides much detail about how the ROMAAD intervention was developed. Furthermore, the approaches used in the development of ROMAAD are described in this chapter, along description of the intervention. Lastly, the elements of the developed intervention are also described in this chapter.

4.1 Development of ROMAAD

Rory's Maths Adventure (ROMAAD) is a mobile game application developed to support the learning of Mathematics in Year 4. It falls under the category of interactive pedagogy tools. It will helps reinforce numerical skills and Mathematics topics that are being taught. The purpose of ROMAAD's attractive and well-designed interface is to attract students in and inspire students to perform better. Practice solving mathematical problems at anytime and anywhere. ROMAAD incorporates multimedia elements such as text, graphic, video and animation. It is an alternative for the existing method to do Mathematic exercise and they also can enjoy learning Mathematic while playing. ROMAAD will focus on providing engaging level to entertain strategic Mathematical thinking both inside and outside the classroom.

The development of this intervention used the ADDIE model as it's base. Keller's ARCS Model of Motivational Design (1987) and Churchill, King, & Fox RASE Pedagogical Model (2013) was used as a framework for creating the motivational elements and the structure of the instructional content. The leaning content of the

intervention, ROMAAD was developed according to the Malaysia Ministry of Education (MOE) 2020 Mathematic Year 4 Syllabus. The overall process of designing and developing the intervention ROMAAD took over a six-month period in three broad phases: analysis, design, development, implementation and evaluation.

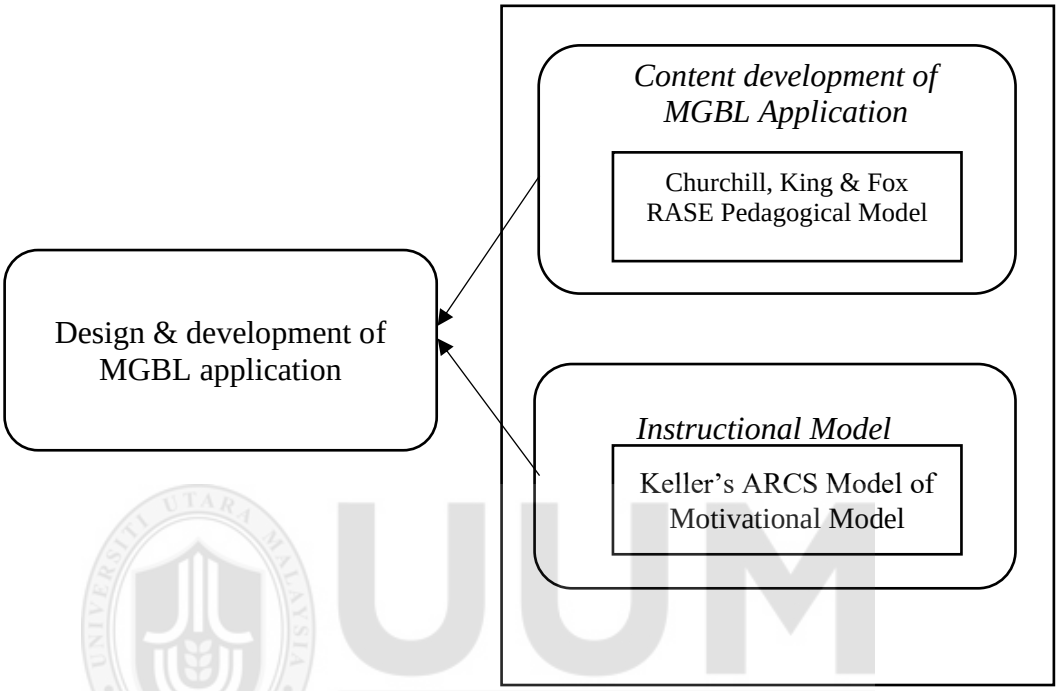


Figure 4.1. Application of Strategies in ROMAAD Design

4.2 ADDIE Model

The development of the ROMAAD is based on ADDIE model. ADDIE instructional design model which was invented by Florida State University (1975) is one of the systematic learning design models. This model is methodically constructed and is based on learning design theory. This model is structured and designed with phases of systematic actions to solve learning obstacles related to instructional materials that match learners' needs and characteristics. According to Widyastuti (2019), the model contains five phases: analysis, design, development, implementation, and evaluation.

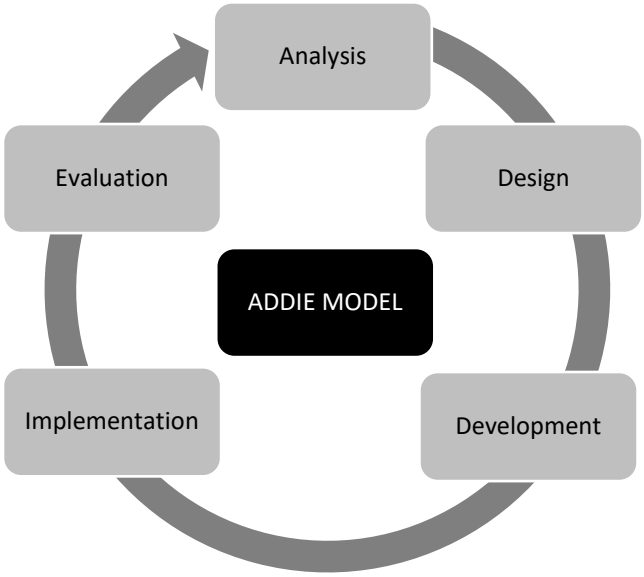


Figure 4.2. ADDIE Model

4.2.1 Analysis

"Goal-Setting Phase" can be considered as the analysis phase (Florida State University, 1975). In this phase the target audience and problem require to be identify. Next, the phase may include certain research methods like task, goal, and need analyses. This phase's output could include a list of tasks that need to be instructed as well as the instructional goals. Throughout the design phase, these outcomes will be used as the phase's input.

In this phase firstly in this stage target audience was identified who is Year 4 Primary school students. Next, to clarify the instructional problems, research was done by reading articles related to game-based learning and the gaps were identified. Moreover, researcher explore related existing game applications in the market. The instructional goals and objectives was established. Requirements were collected and gathered for the intervention development. The requirement were in term of primary and secondary data gathering. For primary data gathering consist of qualitative and

quantitative method. Whereas for secondary data gathering content analysis and competitive analysis review was done.

4.2.1.1 Requirement Analysis

Requirement analysis was done to gather the requirement for the development of ROMAAD. The target users of this mobile educational game will be the Years 4 students from this school. This section is structured into 2 parts. The first part represents the primary data gathering and the second part represents the secondary data gathering.

i) Primary Data Gathering

This primary data was provided by primary school Mathematics teachers. Two methods had been used to gather the requirements which are face to face interview (qualitative) and questionnaire (quantitative) methods. Years 4 Mathematics teacher and Head of Mathematics Panel from SJK (C) Kay Sin which is located at Machang Bubok, Bukit Mertajam, Pulau Pinang took part in the interview session. The Head of Mathematics Panel have 20 years teaching experience in Mathematics subject, and based on her experience, problems that faced by Years 4 students in Mathematics subject had been identified. In order to figure out more information about the Years 4 Mathematics, two sets of questionnaires in Chinese and English language had been constructed and given to some Malaysia Mathematics teachers.

An interview session was conducted with the subject matter expert. The expert answered all the interview questions that had been provided by the interviewee based on her own teaching experience. In addition, the questionnaire was created by using Google Form and was distributed into two languages which are Chinese language and

English language. The respondents of this questionnaire focused on Malaysia teachers who have experience in teaching Years 4 Mathematics regardless of type of school. The questionnaire was sent through Email and WhatsApp and the data was collected from the Google Form. The respondents shared their teaching experiences and information about the Mathematics teaching and learning process of the Year 4 students. Many useful suggestions were provided by the respondents and the data was collected to analyse the requirement for ROMAAD development.

Four stages were involved in this phase which is:

- Data collection- In data collecting phase interview and questionnaire was used to collect the data. The data and information were collected from the client through interview session and the interviewer provides information about Years 4 Mathematics students' learning process and some suggestion for the user requirements of educational mobile game. In addition, the questionnaire was created by using Google Form which includes all the possible requirements and suggestions for developing an educational mobile game.
- Data input- The data input was reviewed from the data collected from the respondents and client.
- Data processing- Then the data analysis process was conducted.
- Data output- Data analyzed is used as feedback in developing the educational mobile game which is Rory's Maths Adventure (ROMAAD).

ii) Secondary Data Gathering

The secondary data gathering was collected from the existing mobile game application in the market by using content and comparative analysis.

- **Content Analysis**

Content analysis is systematically analyze the meaning and patterns within various forms of communication, like text, images, videos, and audio recordings. Through this uncover hidden trends, themes, and insights that might not be readily apparent through other methods can be identified (Klaus, 2013). The process starts with defining the research question which is what require to be learned from the content (Klaus, 2013). The research question on the data gathering of this research is on identifying the relevant component for MGBL application. Next is on selecting the data which the type of content requires to be analysed for data gatering. In this research relevant existing Mathematics games was gathered for further analysis. Next step in content analysis is develop a coding scheme which is on classifying and categorised the content from the data. This involves defining the units of and creating categories. In this research five 5) game aspect were identified to categorise the data. In the following step the coding scheme will be applied to the content where in this research the availability of the game aspect was identified from each existing game. In the next step the data will be analysed. For this research the availability of game aspects was analysed to further support on identifying on the relevant components for ROMAAD application development.

In this research, analysis was done with four existing Mathematics games which is "Math Games for 4th Grade", "MathMon Mental Math", "Math is fun games (Year 1-3) and "Zapzapmath: K-6 Maths Games". The gaming aspects was identified and

gathered from the above selected games. Total five (5) game aspects was gather, which is storyline, score, time limit, rewards and levels. However not all the five (5) elements is available in each of the games. Math Games for 4th Grade exclusively includes score and rewards as its components. Conversely, Zapzapmath: K-6 Maths Games incorporates all the mentioned elements except for a time limit. Based on this analysis, ROMAAD was developed to encompass all of the aforementioned elements.

Table 4.1 below shows the summary of content analysis of various applications currently available in the market with ROMAAD.

Table 4.1

Comparison of game elements among the existing games

Game Aspect	Math Games for 4th Grade	MathMon Mental Math	Math is fun games Year 1,2,3	Zapzapmath : K-6 Maths Games	Rory's Math Advent ure
Storyline	No	No	No	Yes	Yes
Score	Yes	Yes	Yes	Yes	Yes
Time Limit	No	Yes	No	No	Yes
Rewards	Yes	Yes	Yes	Yes	Yes
Level	No	Yes	Yes	Yes	Yes

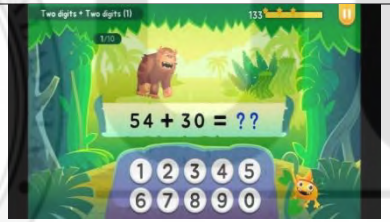
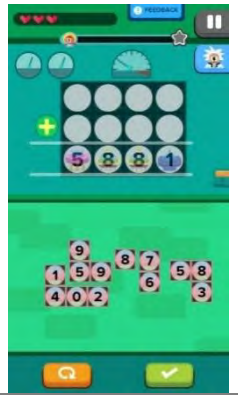
- **Comparative Analysis Review**

Comparative analysis is a powerful research tool used to systematically compare two or more things. It enables you to see connections between them and determine their similarities and differences, providing insights. There are two type of comparative analysis, multiple comparative analyses which focuses on contrasting and comparing

the results of various investigations and single study comparative analyses which is focusing on critically evaluating a specific study (Bryman, 2016). In this research multiple comparative analyses review has been used because for data gathering it requires various existing game comparison to identify components for ROMAAD applications. There are some similar Mathematics based mobile games application in the market for the students. However, there are some attractive elements and features were missing to attract the students to play the game. The summary to the comparison between the existing game that related to this study are described in Table 4.2 Suitable features and elements will be implemented to develop a more user-friendly and an impactful game for Year 4 Students. Hence, Rory's Maths Adventure game will be developed by including all the game elements that stated as above.

Table 4.2

Comparison among the existing games application

	Math Games for 4th Grade	**MathMon Mental Math**	**Math is fun games Year 1, 2,3**	**Zapzapmath: K-6 Maths Games**
Icon				
Interface				
Description	This game includes Math curriculum for 4th grader inside the Mathematics apps such as additional games, subtraction games, fraction	This mobile game is suitable for all ages and it can play at anytime and anywhere. People who feel bored with learning calculation and who wants fun	This game helps develops the mental Math skill and promote brain training. Kids can learn counting, addition, subtraction, multiplication,	The user of this application will explore a cosmos with more than 180 games covering more than 180 math-related subtopics. In

	games, multiplication games, division games, number patterns, number sentences and number introduction up to 100000. This game is created for elementary school and it suitable for kids to play. By playing this game will increase user's Math skill and surpass other people. User no needs to use Math calculator or any additional material such as multiplication worksheets and Math book.	brain-training can go through this mobile game. This game can help those people who calculate slow and make many mistakes to improve their mental Math. User can mark the answers in real time, check the overall learning process and find weakness by playing this game.	division, fraction and all mixed operation. This is a cool multiplayer game for kids (Math Online) that allows kids from everywhere in world to play game with each other in the world. Kids can also play with computer and it has four levels which is easy, medium, hard and hardest	order to grasp mathematical principles, users go to different planets and perform a range of obstacles. A wide range of mathematical topics are covered in ZapZap Math, which is presented in an organized, module-oriented style.
Rating	3.7/5.0	4.6/5.0	4.0/5.0	4.3/5.0
Language	English	English	English	English
Multimedia Elements	Text, audio, graphic	Text, image, audio, animation	Text, image, sound effect, animation	Text, image, sound effect, animation
App size	44.96MB	103 MB	54.82MB	89.36MB

4.2.2 Design

The second phase of the development process is designing the MGBL application which is Rory's Maths Adventure (ROMAAD). Using the results from the Analysis phase, the design phase involves developing an instruction design plan. In this stage, the researcher outlines to expand the instructional goals to meet the learning objectives identified in the Analysis phase.

In this study, the intended users were Year 4 Primary school students, and the learning outcome were to enhance Mathematical problem-solving skills. In this phase, the idea was translated into a draft form based on the requirement analysis. Firstly, content idea was designed and developed on learning objective and identification of multimedia elements for the instructional model. The content ideas were developed based on structured functional and non-functional requirements.

Next, based on that storyboard was developed to visualize the content idea. A storyboard is a collection of screen drawings that show how to arrange the content and flow of an instructional material. The storyboard consists of organised visual representation of the product design that include the details of all multimedia elements which is text, graphics, audio, video and animation. The storyboards in this study are basic graphical sketches that provide an approximate overview of the final product that will be created. In this study, the storyboarding is classified as a low-fidelity throwaway version, which used as the developer's guide for describing the navigation and interaction features, audio and video material, and presentation elements on each screen of ROMAAD. It supports the developer in structuring and determining the best medium to utilize for each component of ROMAAD, as well as defining the parameters of the project within the constraints of time and resources.

Figure 4.3 displays an example of the ROMMAD application storyboard layout. The complete storyboard drawings are included in Appendix E.

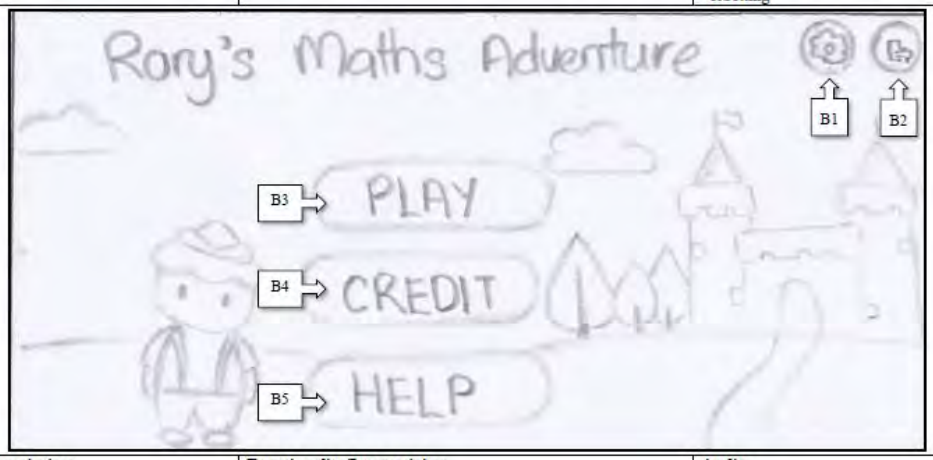
Screen: Screen 3 (Main Menu)	**Links from screens:** Storyline	**Links to screens:** Select level, Credit, Exit &Setting
		
Screen Description:	**Functionality/Interactivity:**	**Audio:**
Main menu content three type of buttons which will link to another page.	B1: Link to setting screen B2: Link to exit screen B3: Will link to choosing level page B4: Link to credit page B5: Will link to help page	- Background music - Button clicking sound

Figure 4.3. Sample Layout of ROMAAD Storyboard (Menu)

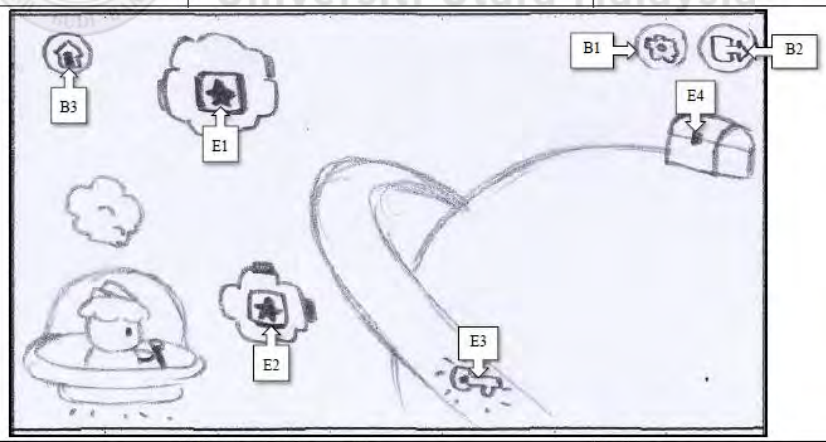
Screen: Screen 25 (Level 7 Gameplay)	**Links from screens:** How to play level 7	**Links to screens:** Select level & Question pop-up
		
Screen Description:	**Functionality/Interactivity:**	**Audio:**
This screen will display level 7 gameplay in space where the player must collect all the object to answer the question and find key to open the treasure box and answer questions provided to proceed to next level	B1: Link to setting screen B2: Link to exit screen B3: Select Level E1: Link to pop-up question E2: Link to pop-up question E3: Key to unlock level E4: Unlock treasure box and link to next level	- Background music - Button clicking sound - Object collecting sound effect - Walking sound effect

Figure 4.4. Sample Layout of ROMAAD Storyboard (One of the Game Interface)

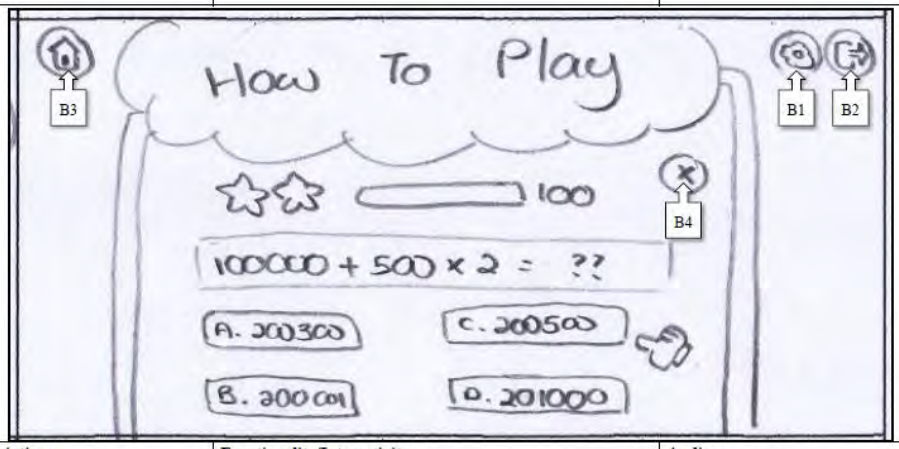
Screen: Screen 22 (How to play level 6)	Links from screens: Select level	Links to screens: Level 6 Gameplay
		
Screen Description:	**Functionality/Interactivity:**	**Audio:**
This screen will display instructions how to play level 6. This tutorial will be in video format so that player can understand the gameplay in detail.	B1: Link to setting screen B2: Link to exit screen B3: Link to main menu B4: Skip to Gameplay	- Background music - Button clicking sound - Sound from tutorial video

Figure 4.5. Sample Layout of ROMAAD Storyboard (Question)

The storyboard has been divided into several separate sections. The developer must create the actual instructive text messages that users of the program will encounter. This comprises both the main text and supporting text, such as exit messages, menus, prompts, hints, transitions, and guidance (Alessi & Trollip, 2001).

Planning other output, such as sound, background music, and narration, as well as drawing and revising visuals like graphics, animations, and videos, is crucial. The storyboard documents do not produce sound and graphics, as opposed to text. The elements are only briefly described in the storyboards. The primary school's subject matter and content experts also reviewed the storyboards that were developed. This is done to check the sequence, clarity of the text and graphics, accuracy of the content, and other details. The storyboards were revised again in response to the feedback from the reviewers in order to create an instructional material that are both efficient and effective.

4.2.3 Development of ROMAAD

Multimedia elements based learning is require to develop and improve students' competencies efficiently and effectively (Untari, Kamdi,Hadi & Nurhadi, 2020). In the development phase, the content was developed based on the multimedia elements using suitable software which includes computer programming for functional program, graphics, text, audio, animation and video materials. Creating a functional system from the storyboard and prototype is the task of the development phase. Each of the development of the elements describes as below.

i. Text, Graphics and Animation: Firstly, all the required graphics content was developed by using Adobe Photoshop and Illustrator in two dimensional (2D), such as character, obstacles, enemies, backgrounds, buttons and text. Next, 2D animations were also used in ROMAAD. These animations were created using Adobe after effects and in unity. For the text, the fonts were downloaded online based on suitability of the ROMAAS concept.

ii. Video and Audio: ROMAAD also contains video clips elements. These videos were intended to show the animated storyline, how to play and tutorial video, which are difficult to illustrate using graphics/still images and only animations. The video production and editing were done by using Adobe Premiere and After effects. The video clips were originally in.avi format, but were later edited and converted to.MP4 format in order to minimize file size.

After all the required multimedia elements such as graphics, text, audio, animation and video materials were produced based on the requirements and storyboard, all of it were integrated to develop ROMAAD. Development of ROMAAD was created by

using Unity software. Unity is a game engine capable of developing computer, console or mobile game (Sarosa, Chalin,Suhari, Sari & Hakim, 2019).

Figure 4.6. Interface of unity used to develop ROMAAD

The development part of this study involves developing and providing instructions with relevant information for the study's end users, which are the students and the teacher. The supporting materials come in three different forms: operating manuals, student manuals, and instructor manuals. However, for this study, only one operating manual was created that can be used by all users.

Rory's Maths Adventure (ROMAAD) mobile game application was developed and try to bridge the research gap as it focusses on Malaysia Year 4 Mathematics syllabus. The purpose of design this mobile game is to help the student increase their Mathematics problem solving skill and perceived motivation. This mobile educational game can be a supplementary exercise to motivate them to do more practices in Mathematics. Besides that, users will challenge themselves by demonstrating and processing the Mathematic knowledge while playing the game but not stressing over

how to win the game. Evaluation was conducted by using expert review that is Interface expert and content expert.

4.2.3.1 Expert Review

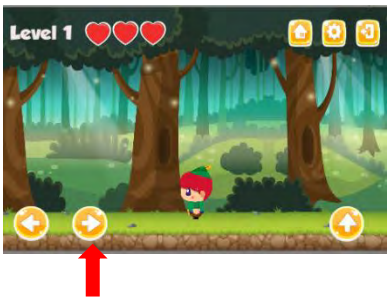
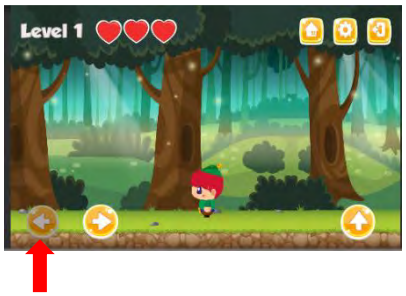
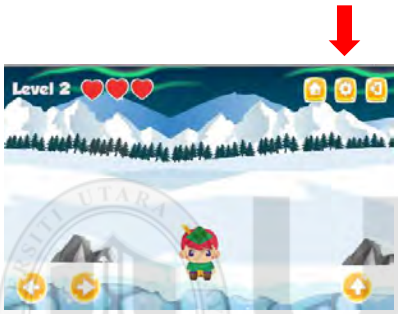
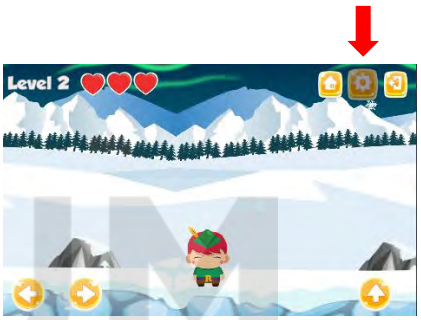
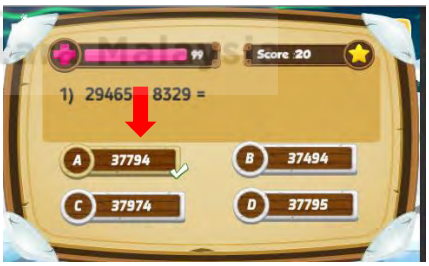
Face-to-face interviews served as the main instrument for the evaluation, which used qualitative approaches. Four (4) major dimensions make up the evaluation: content, demographics, interface design, and usability. To evaluate the application, a panel of experts was created, consisting of three interface experts and one content expert. Different interview methods were designed for each dimension to enable an organized evaluation. The chosen experts were interviewed, and the information collected underwent analysis to determine the usability of the mobile game. The procedure included choosing the experts, making meetings by email and WhatsApp, and holding interviews with prewritten questions. Participants included subject matter and interface experts with relevant experience. Together, they assessed the content, interface, and usability features with the intention of identifying and resolving any immediate problems using their expertise in human factors, usability guidelines, and design principles.

i) Usability

Suitable effects and animations for buttons has been added based on experts' requirement. There are also some explanations for lives icon has been added so that player can understand well about representation of the icons.

Table 4.3

Illustration of before and after the improvement made on the usability

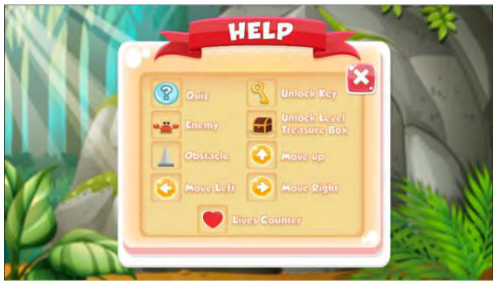
Before **There is no animation higlight effect on the buttons**	After **Animation highlight effect has been added n the button**
	
	
	

ii) Game play

Based on the expert's requirement scoreboard has been added and developer named it as "Starboard" because the scores represent as star at end of the game where it will determine the winning level according to the stars collected.

Table 4.4

Illustration of before and after the improvement made on the game play

Before	After
Missing of "Life icon" in the help interface 	"Life icon" has been in the help interface 

Based on the evaluation result some animation video for the mathematics question tutorials was created and added so that player (Year 4 students) can refer to the video if they can't able to answer the question.

Figure 4.7. Mathematics Question Tutorials

All the input for the expert review were taken into consideration and the improvement was done accordingly.

4.2.4 Pilot Study

4.2.4.1 Implementation

In the implementation phase, ROOMAD was implemented among 37 Year 4 students which consist of Year 4 students from SJK (C) Kay Sin. Firstly, the respondents were given some briefing regarding purpose and objective of the evaluation on Rory's Maths Adventures and a user manual was distributed. Then, the respondents were divided into two to three members in a group and each group start playing the game for 30 minutes alternatively prior to provide their feedback. The detailed implementation was explained in chapter 3.7.4.

4.2.4.2 Evaluation of usability study of ROMAAD

In the evaluation phase all usability survey was carried out in terms of use of use, ease of learning, consistency, information structure & design activities and satisfaction. A set of questionnaires was distributed after the students' play the game for 45 minutes, explanation and guidance was given prior to take part in the survey about the questionnaire, given that the participants are still young and may find it challenging to fully understand the questions. To make the respondents easier to understand the questions, the questions was created in dual language that is English and Chinese. They took around 5 to 10 minutes to participate in this survey and the overall survey took almost 1 to 2 hours. The gathered information was then entered into a Google Form to facilitate the study of the whole amount of information gathered. The recorded data then checked for completeness and analysed to obtain useful information.

The major finding of the usability survey reveals that in mobile game-based learning (MGBL), ROMAAD is a beneficial MGBL application for years 4 students. By using

ROMAAD in mathematics lessons to improve students' problem-solving skills, it benefits them and helps them to enhance their Mathematics problem solving skills. Additionally, ROMAAD stimulates teacher's interest, student motivation, and engaged participation. Additionally, teachers can make the most of ROMAAD to teach mathematics more successfully because it has text, image, audio, video, and animation elements that can encourage students to learn Mathematics quickly and efficiently. The use of ROMAAD in the classroom enhances the curriculum and helps students get the most out of their class time. For instance, the application of ROMAAD emphasizes student engagement and enhances teacher-student communication. As a result, ROMAAD offered students an innovative and appealing way to study mathematics and a chance to enhance the conventional classroom teaching paradigm.

4.2.4.3 Results and Findings

Post evaluation, analysis and decoding were performed to discover the remarks and feedback from the specialists to improve the ROMAAD primarily based on the feedback. Below are the summary of the evaluation according the aspects.

Table 4.5

Summary of expert review

Aspect	Comments
	Game Background - Expert users comment that the game background and graphics is very nice and suitable for the game. Font type - All the font type, size and colour are suitable according to the background.

Interface Design	UI Buttons - Expert users gave good review about the button type and size that used in the game. One of the experts suggested to add button effect/ animations so that the users can feel when click the button. Background Animation - Expert gave good comment on background animation that been used in all the level of the game. All other minor animations also had good review from the expert.
Usability	Navigation and Game flow - Experts found that all the navigation and game flow can be easily understand without any complication. Furthermore, they found that buttons and icons used are understandable and the kids can understand the game flow. - One of the experts suggested to add explanation in help menu on lives icon in the game. Functions of the UI Buttons - All the buttons can function well and navigate correctly. Function of the controller button for the movement - Majority experts said that the character can move smoothly according to the controller. But one of the experts feel some difficulty when pressing jump and left/right button together.
Extra Comment	- Expert suggested to have scoreboard end of the game. - Commented to add some tutorials for method to answer Mathematics question. - One of the experts suggested to add psychomotor method in the game

Content	Syllabus that used in all the question - Content expert commented that the content is suitable with the syllabus all the question was in hundred thousand, so it was suitable. Time provided to answer the questions. - The time given (100 sec) is enough for them to answer but the expert suggested to have 2 minutes for answer long questions. Gameplay/Storyline - Expert gave good comment on the gameplay that the game flow and game play is very interesting and suits year 4 student. Game tutorial video - The game tutorial easily can understand by the students. Other Suggestion - Content expert suggested do create in 3 languages Chinese, Malay and English.

4.3 Implementation of Keller's ARCS Model of Motivational Design

The design of ROMAAD's instructional material structure and motivational features was based on Keller's ARCS Model of Motivational Design (1987). This model is a well-documented design that contributes significance to the motivation viewpoints of the students and has been widely used in educational materials (Means, Jonassen, and Dwyer, 1997). (Plants & Sorensen, 2004). This theory serves as a framework for developing and communicating a unit of guidance that stimulates learning, which makes it particularly persuasive when it comes to the planning and preparation of educational materials (Keller, 1987).

The ARCS model offers a very basic and purposeful development of educational gains that can be implemented into the architecture of ROMAAD, which is why it was chosen to create the content for the program. The ARCS model's ability to facilitate information transfer across memory stages is one of the main reasons it was chosen for this ROMAAD development (Keller and Suzuki, 1988). The essential elements of instruction are encapsulated in it, including individual differences, motivation, perception, feedback, reinforcement, retention, and information transfer (Keller, 1983, 1999).

In this study, Keller's ARCS Model of Motivational Design was used as guide for the instructional content design of ROMAAD. When creating engaging educational content, the four ARCS model elements of attention, relevance, confidence, and satisfaction are essential.

Gaining and maintaining the student's attention is the first and most crucial component in the ARCS methodology. According to Keller (1987), strategies for doing this can include straightforward, unexpected events like a loud whistle or various components that excite students' curiosity on a deeper level. In this study, ROMAAD's allows the users to refer to the tutorial video while solving the question which helps to improve self-learning and the graphics, animation and background music were used to catch the students' interest at the beginning of the content, and different multimedia components were used to keep their attention throughout the presentation of the content.

Building relevance is the second element. Without relevance, it will be difficult to keep students interested and motivated (Keller, 1987). The students should be able to relate to the specific subject and feel that it is important and beneficial to them. In

ROMAAD the contents relate with students daily educational at school which could help to improve their education in that specific subject and this incorporated with a fun learning experience as expected by young learners.

Next, the ARCS model's confidence component is necessary for students to feel motivated to participate in the lesson and create positive success expectations. In this study unlocking each level in ROMAAD will motivate and make them believe that they have learned and achieved on the specific topics which can boost their confidence. According to Keller (1987), students should be in control of the lesson and the amount of time needed to finish it to increase trust in a technology-based instructional material application. Based on that ROMAAD, was designed and developed to give the students full control and capacity to self-navigate throughout the game completion and suitable time was given for them to answer all the question. They also have accessibility to redo the chapter as for revision purpose.

The final component in ARCS model is satisfaction. Satisfaction refers to positive feelings about one's accomplishments and learning experiences (Wang, Tian & Huebner, 2019). This can come in the form of enjoyment or a feeling of accomplishment, like scores or a completion certificate. In ROMAAD the score for each question, level, and final reward will give them satisfaction feel where they could believe that have learned and revised the mathematics subject. Table 4.8 Present the application of the ARCS Model of Motivational Design Components to the design of ROMAAD.

Table 4.6

ARCS Model of Motivational Design Components to the design of ROMAAD

ARCS	ROMAAD
Attention	Elements
Relevance	Content
Confidence	Interactivity
Satisfaction	Feedback

Table 4.7

Summary of strategies and application of the ARCS components in the ROMAAD design.

ARCS components	**Strategies**	**Application in ROMAAD**
Attention	Strategies for arousing, Sustaining students' engagement and curiosity.	Graphics, animations, totrial videos and how to play videos
Relevance	Strategies that are related to the goals, objectives, and interests of students.	Incorporation of multimedia elements relevance to the subject syllabus.
Confidence	Strategies that help students develop a positive expectation for successful achievement.	Unlocking each level in ROMAAD. Accessibility to redo the chapter as for revision purpose
Satisfaction	Strategies that offer both internal and external rewards for the effort	The score for each question, level, and final reward will give them satisfaction feel where they could believe that have learned and revised the mathematics subject.

4.4 Implementation of Churchill, King, & Fox RASE Pedagogical Model

The pedagogical student-centered learning model used is called Resources, Activity, Support, and Evaluation (RASE). The RASE model was developed by Churchill,

King, and Fox in 2013. Since the RASE model was developed based on problem-solving (Jonassen, 2000), engaged learning (Dwyer, Ringstaff & Sandholtz, 1985-1998), problem-based learning (Savery & Duffy, 1995), rich environments for active learning (Grabinger, 1996), technology-based learning environments (Vosniadou, 1995), interactive learning environments (Harper &Hedberg, 1997; Oliver 1999), theoretical concepts, and more, it will be used to design this MGBL application.

In this study, the RASE model was used as a foundation to achieve the intended learning outcome in terms of problem-solving skills and because it is that the pedagogical model developed for a student-centered and authentic curriculum. The main focus of the RASE model is on how best to use or integrate the technology to boost student learning and satisfaction (Churchill, King & Fox, 2013; Churchill, King, Webster & Fox, 2013).

The RASE model consists of four major elements: Resource, Activity, Support, and Evaluation. Incorporation of ROMAAD with this model is illustrated as shown in Figure 4.8

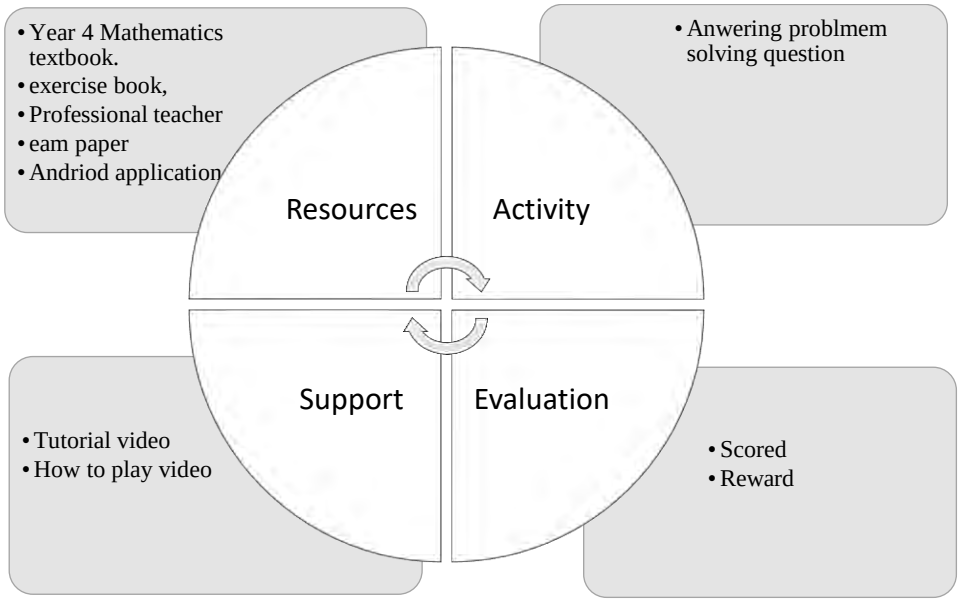


Figure 4.8. RASE Pedagogical Model

The four constructs in the pedagogical model indicate in collaboration with ROMAAD application as below table:

Table 4.8

Collaboration of Pedagogical model with ROMAAD application

Construct	Elements in the application	Explanation
Resources	Content & Tools	The content will be developed to engage students in Mathematics learning. It includes. **Content**: Year 4 Mathematics textbook, exercise book, professional teacher handouts, and exam question. **Tools:** Android application and online application.
Activity	Question	Learning experience using resources (MGBL). Mathematics questions will

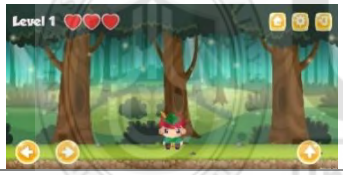
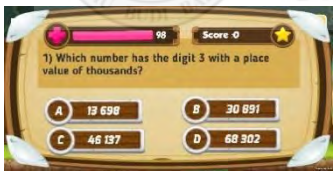
		be the main learning activity. These activities are learning experiences where students can improve and learn on understanding, test ideas and apply knowledge in terms of problem-solving skills and more. Good learning activities able students to develop their learning and achieve learning outcomes.
Support	Tutorial Video	In MGBL, the support will be in the state of student-learning resource where it will be provided with some video tutorials which can lead to self-learning. Moreover, students will be able to improve their perceived motivation towards the MBGL application. This is because there is support for them to perform the main activity.
Evaluation	Scores and reward	This MGBL application will provide a captivating method of evaluation in terms of scores rewards and more.

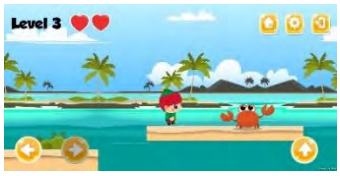
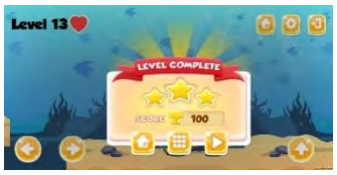
4.5 Features of ROMAAD

In this study, ROMAAD was designed and developed based on multimedia elements. ROMAAD contains text, graphics, video, animations and audio. Table 4.11 illustrates the screenshot and interface of the multimedia elements used in ROMAAD.

Table 4.9

Screenshot and interface of the multimedia elements in ROMAAD

Screenshot	Interface	Multimedia elements
	Storyline Interface	• Video • Animation • Audio & Music • Hover button with animation
	Main Menu Interface	• Audio & Music • Hover button with animation
	Game Level Interface	• Music • Hover button with animation
	Level1 Interface	• Animation • Music • Hover button with animation
	Question type 1	• Music • Hover button with animation • Video upon click “I” button
	Question type 2	• Music • Hover button with animation • Video upon click “I” button
	Question type 3	• Music • Hover button with animation • Video upon click “I” button

	Obstacle Interface	• Animation • Music • Hover button with animation
	Award Interface	• Animation • Music • Hover button with animation
	Game over Interface	• Animation • Music • Hover button with animation

4.6 Flow and structure of ROMAAD

A variety of mathematics questions are included in the MGBL ROMAAD, so that students may explore the subject matter on their own. ROMAAD has 18 levels, with each level representing a different chapter from the Year 4 Mathematics curriculum. Every level has a unique background that is themed differently. As a result, when players unlock each level, the game's theme can change.

The opening of this game tells the tale of how the protagonist, Prince Rory, began his adventure. The narrative can capture users' interest, provide them a better knowledge of the game, and enable them to play with excitement. If the user has played the game before, they are permitted to skip the tale. After the user hit the skip button, the main menu interface was displayed. The major buttons on this interface are "Play," "Help," and "Credit," and the main menu interface also has "Setting" and "Exit" buttons.

Game level interface will open after they click the "play" button. If the user successfully unlocks all the levels, then they it will allowing them to choose the level they like. But, if the user is unable to unlock the current level, they cannot move on to

the next one. This approach makes users push themselves to finish each level in order to advance to the next level.

The "left," "right," and "up" arrow buttons of the ROMAAD game controller are used to direct character movement. Each level's mathematics questions are represented by bubbles on the gameplay platform. Three different game modes, including drag and drop, keying in the answer, and multiple choice, are available for answering the questions. To collect the key and unlock the treasure box, players must collide with every bubble in each level in order to answer all the questions within the given timeframe. If the user provides the correct response, their score will rise by 20 points; if they provide the incorrect response, their score will fall by 5. When users have completed answering.

The level's difficulty increase as the level does as well. To make the gameplay more tough and exciting, enemies and moving platforms will be included. A scoreboard displaying the total number of stars earned across all levels will appear once the user has finished all the levels. The plot for the game will end with a video clip being played. However, the game's finale will vary depending on the user's final score and number of stars. In fact, at the conclusion of the story, Price Rory will receive a silver crown, gold crown, or massive gold crown.

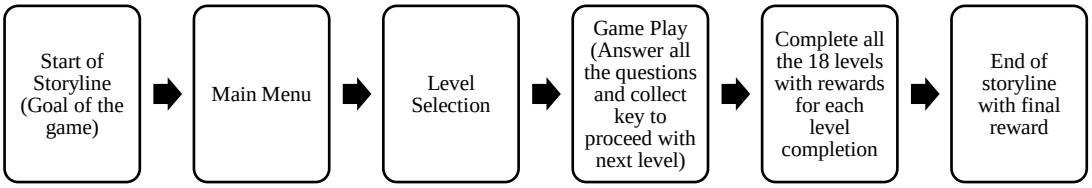


Figure 4.9. Summary of game flow

4.7 Summary

The design and development of the ROMAAD that was utilised as the treatment mode in this study are covered in detail in this chapter. The analysis, design, development, implementation and evaluation phases of the ADDIE model approach served as the primary means of guidance and instruction for developing ROMAAD. The content design was based on Churchill, King, & Fox RASE Pedagogical Model. Keller's ARCS Model of Motivational Design (1987) also provided comprehensive guidelines for the creation and development of the instructional material structure and motivational elements. This chapter also explains the components, flow and structure of the intervention that was developed as a guideline for this study. The next chapter explains on the result and findings of the research.

CHAPTER 5

RESULTS

5.0 Overview

The chapter provides the outline of the findings from the research that examine the effect of Mobile-game based application ROMAAD on Year 4 students. 314 students from six (6) primary school were chosen as respondents in this study as three (3) school was selected as experimental groups whereas another three (3) schools under control group. These two (2) groups were compared for their significant difference in Mathematics problem solving skill and moderated by their thinking style. For experimental group, their perceived motivation of the ROMAAD application were also examined. Whereas for the control group only Mathematics problem-solving skill was examined.

Parametric statistical methods including descriptive statistics, paired T-tests, and analysis of variance (ANOVA) were applied to analyze the data. The Statistical Package for Social Science (SPSS) program was used to perform these statistical analyses. Every hypothesis that was developed for this investigation was examined at a significance threshold of $p < 0.05$. In the analyses, the null hypothesis is rejected if the p-value is less than or equal to 0.05, and it is failed to be discarded if the p-value is greater than 0.05. A p-value of less than or equal to 0.05 in this study suggests that the problem-solving ability and reported motivation of the experimental group respondents are significantly impacted. The results of the descriptive and inferential statistical analyses are presented together with a thorough explanation. Lastly, a summary of the research hypotheses' findings was presented.

5.1 Characteristics of the Sample

The sample for this study were 314 Year 4 students from six primary schools. The samples were randomly divided into two groups which is experimental group and control group. Three (3) experimental group was given the ROMAAD intervention, which consist of 175 students and 139 students were under three (3) control group who remained with the existing method of learning/revision. Table 5.1 shows the descriptive statistic of the 2 experimental and control groups used in this study.

Table 5.1

Sample Distribution for the Groups

Group	Number of students	%
Experimental	175	55.73
Control	139	44.26
Total	314	100

5.1.1 Homogeneity of the two groups

The students from six (6) primary school chosen for this study were similar term of education level which is Year 4. The sample subjects were homogenous in terms of their technology exposure and from schools within a similar geographical area which is urban. This is because respondents from the urban area are the ones who have more technology exposure and implement dual-language mathematics subjects in schools than in rural areas. In an effort to ensure that the students in this study are homogeneous while examining the effects of ROMAAD on problem-solving skills, perceived motivation, and thinking style, the homogeneity of the two groups was statistically analysed. To determine if the error variance in the pre-test score was the same for both groups, a Welch's t-test was conducted, assuming unequal variances of

both groups due to the population sample. A two-population mean equality test is performed using Welch's t-test. This test is typically used when two populations differ from one another and when the sample sizes of the two populations are not the same. In this study sample from both experimental and control group is not equal due to availability of the student in that specific school and class. Hence this Welchs test require to be used for homogeneity test of the two groups. The Welch's t-test is demonstrated in Table 5.2, which satisfies the equal variance assumption for parametric statistical analysis by supporting the homogeneity of variance assumption (p=0.082).

Table 5.2

Illustration of Welchs t-test

df1	df2	Sig
1	312	.082

Table 5.4 presents the results, which demonstrate that the p-value of 0.082 is more than 0.05 (p>0.05), signifying that there is almost equal variation in the pre-test scores between the control and experimental groups. Since the students' prior knowledge of mathematics problem-solving techniques was homogeneous prior to the treatment, any improvements in the experimental groups' problem-solving skills may have been due to the educational materials utilized.

5.1.2 Classification of Students as Analytical thinking or Holistic thinking

The sample of 314 Year 4 students from 6 primary schools who participated in this study was randomly assigned into 2 groups which is experimental group and control group. Thus, the distribution of the thinking style for both groups was randomized. The students were classified by their thinking style using the adapted version of The

Scale of Holistic and Analytical Thinking (SOHAT) (Umay & Ariol, 2009) instrument. The students SOHAT scores was analysed using descriptive statistics and the results are shown in Table 5.3.

Table 5.3

Descriptive Analysis for SOHAT

Variables	Mean	Std. Deviation	Std. Error Mean	Minimum	Maximum
Thinking Style (n=314)	9.3407	2.0399	0.115	5	15

*n denotes number of students

The total mean score for SOHAT is 9.34. According to the calculated mean score, the sample were categorized as analytical thinking or holistic thinking. Students with the SOHAT score 5-8 were categorized as analytical thinking whereas students with score 9-15 were categorized as holistic thinking (Umay & Ariol, 2009). The number of students in each category of thinking styles described in Table 5.4

Table 5.4

Total number of students based on thinking style VS groups

Moderator Variable	Experimental group	Control group	Total
Analytical Thinking	45 (25.71%)	44(31.65%)	89
Holistic Thinking	130(74.28%)	95(68.35%)	225
Total	175	139	314

Table 5.4 indicated, from Total 175 student under experimental group who used the ROMAAD application, 45 students is with analytical thinking and 130 students with holistic thinking style. Whereas for control groups 44 students were identified as analytical thinking and 95 students as holistic thinking. From the overall number of

314 students, 89 students were classified as analytical thinking and 226 students as holistic thinking.

5.3 Statistical Analysis of Results Corresponding to Research Questions

This research was designed to address four (4) research questions based on mathematical problem-solving skills, perceived motivation and thinking style as below.

1) What are the relevant components for the mobile game-based learning application to improve students' mathematical problem-solving skills and their perceived motivation?

2) How do these components interrelate into the design and development of a mobile game-based learning application that can improve students' mathematical problem-solving skills and their perceived motivation?

3) What is the effectiveness of the mobile game-based learning application that can improve students' mathematical problem-solving skills?

4) What is the student's perceived motivation on the instruction material?

5) What is significant effects of students' thinking style on their mathematical problem-solving skill?

6) What is significant effects of students' thinking style on their perceived motivation of the instructional material?

To achieve the objective, six research questions were created. From these research questions, four hypotheses were formulated. Research question 1 and 2 has been answered detailed in chapter 4. This section attempts to answer research question 3-6. Hypotheses of this study are formulated as a null hypothesis. The hypotheses were

formulated as null hypotheses. The default assumption known as the null hypothesis states that there is no significant connection or difference between the variables under investigation. It is stating that there is no effect or association between the variables. Based on this study there are not any exiting research in the market shows on the effectiveness of the game-based learning on Mathematics problem-solving for Year 4 students. Hence, null hypothesis was used as below:

H_{03}: There is no effect of using ROMAAD application on the improvement of students' mathematical problem-solving skills.

H_{04}: There is no significant interaction of the students' thinking styles on the use of ROMAAD application to improve students' problem-solving skills.

H_{05}: There is no effect of using ROMAAD application on the students' perceived motivation for the instructional material.

H_{06}: There is no significant interaction of the students' thinking styles on the use of ROMAAD application on the students' perceived motivation of the instructional material.

The following section will prove the hypothesis based on the findings.

5.3.1 Testing of Hypothesis H_{03a}

H_{03}: There is no effect of using ROMAAD application on the improvement of students' mathematical problem-solving skills.

Hypothesis $H_{03,}$ investigate the independent variable, Mobile game-based application (ROMAAD) on the dependent variable, Mathematical problem-solving skills. In order to investigate ROMAAD application has effect on Mathematical problem-solving skills, an ANOVA analysis was carried out on the problem-solving scores. These

mathematical problem-solving techniques were developed based on the variations between the pre- and post-test results. Before the inferential statistical analysis, the mean and standard deviation of the experimental and control groups' scores on the pre-, post-, and mathematics problem-solving tests were discovered. Table 5.5 Shows descriptive statistic for Pre-test and Post-test by groups.

Table 5.5

Descriptive statistic for Pre-test and Post-test by groups

Group	Score	*n	Mean	Std. Deviation	Std. Error of Mean
Experimental group	Pre-test	175	8.58	5.5	.31
	Post-test	175	9.35	5.9	.33
	Problem Solving Skill	175	.77		
Control group	Pre-test	139	8.02	5.01	.42
	Post-test	139	7.72	5.30	.44
	Problem Solving Skill	139	-.3		

*n denotes number of students

From the above descriptive statistical analysis, it shows that 175 students was assigned under experimental group whom used ROMAAD application and 139 students under control group whom remain with existing education method. For experimental group the mean for Pre-test score is 8.58 and the mean for Post-test score is 9.35. As for control group, the mean for Pre-test score for is 8.02 and the mean for Post-test score is 7.72. The difference of mean score between the Pre-test and the Post-test score for experimental group is 0.77. This indicate that improvement in term of solving

problem-solving questions. The mean scores determined that students who use ROMAAD application under experimental group obtained higher problem-solving skill score as the problem-solving score for experimental group is 0.77 compared to control group which is -0.3. This also stipulate that the students who used ROMAAD application scored higher on the mathematics problem-solving questions compared to the students who used existing method who is under control group. This shows that the students have improved their Mathematical problem-solving skills when they used ROMAAD application.

To perform detailed investigation on the hypothesis, an ANOVA test was conducted to see if there is effect in Mathematical problem-solving skill among the students who used ROMAAD application. Table 5.6 Illustrates the ANOVA analysis result.

Table 5.6

ANOVA analysis result on Mathematical Problem-solving skills

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	246.96	1	246.96	7.000059	0.008	3.868319
Within Groups	12277.34	348	35.2797			
Total	12524.3	349				

Table 5.6 describes the effectiveness of ROMAAD for experimental group. The magnitude of the differences in the mean of pre-test and post-test for experimental group is 0.77. The p-value is 0.008, which is $p<0.05$, indicates that there is effect in problem-solving skill among the students during pre-test(Mean X n = 8.58, Standard Deviation SD = 5.5) and post-test (Mean X n = 9.35, Standard Deviation SD = 5.9) as shown in Table 5.4. Hence, Hypothesis H03 which is no effect of using ROMAAD

application on the improvement of students' Mathematical problem-solving skills rejected. This indicates that students who used the intervention have improvement in their problem-solving skills.

In summary, the statistical analysis demonstrates that the use of ROMAAD application has a positive impact on the improvement of students' mathematical problem-solving skills. Hence, it can be concluded that the students in the experimental group exhibited greater improvement compared to those in the control groups.

5.3.2 Testing of Hypothesis H_{03b}

H_{04} There is no significant interaction of the students' thinking styles on the use of ROMAAD application to improve students' problem-solving skills.

Statistical analysis was carried out to see if there was a significant interaction between moderator variable, analytical thinking and holistic thinking on the use of ROMAAD application to improve students' problem-solving skill among experimental and control group's students. The descriptive statistical are presented in Table 5.7

Table 5.7

Descriptive statistical of thinking styles by group

Thinking Style	Group	*n	Mean	Std. Deviation	Std. Error Mean
Analytical Thinking	Experimental	45	7	0.8	0.1
	Control	44	6.77	1.05	0.15
	Total	89			
Holistic Thinking	Experimental	130	10.3	1.6	0.2
	Control	95	9.7	1.4	0.2
	Total	225			

*n denotes number of students.

Table 5.7 Signified that 45 analytical thinking and 130 holistic thinking students used ROMAAD application who is under experimental group. For control group, 44 students are analytical thinking and 95 students holistic thinking.

Table 5.8

Thinking style vs problem-solving skills improvement analysis

Thinking Style	*n	Improvement		% of Improvement
		Yes	NO	
Analytics	45	29	16	64.4%
Holistic	130	96	34	73.84

Table 5.8 shows the percentage of problem-solving skills improvement for students under experimental group based on thinking style. From total 45 analytical thinking students 64.4% of students have improved their problem-solving skills upon using

ROMAAD. Whereas 73.84% from 130 holistic thinking students improved their Mathematics problem-solving skills upon using ROMAAD.

To determine the significant interaction of the students' thinking styles on the use of ROMAAD application to improve students' problem-solving skills, pairwise comparison was done. The results of the analysis are shown in Table 5.9

Table 5.9.

Analysis of the students' thinking styles on the use of ROMAAD application to improve students' problem-solving skills

Thinking Style/Group	Thinking Style/Group	*Mean Difference*	*Standard Error*	*Sig*	*95% Confidence Interval For Difference*	
					Lower	Upper
AT_E	AT_C	.779	94.802	2.899	0.089	3.856
HT_E	AT_C	1	96.025	2.938	0.086	3.856

The pairwise analysis result revealed that there is no significant interaction between students thinking styles and students' improvement in problem-solving skills in using ROMAAD application EH (p=0.0891) and EA (p=0.0869) which is less than the standard significance level of 0.05. Hence, the $H_{04a\ null}$ hypothesis failed to be rejected, indicating both thinking styles, analytical thinking and holistic thinking does not have any interaction and effect on students' problem-solving skills by when using ROMAAD application.

5.3.3 Testing of Hypothesis H_{04a}

H_{05}: There is no effect of using ROMAAD application on the students' perceived motivation for the instructional material.

Hypothesis H_{05} examined the effect of independent variable, ROMAAD application on the dependent variable, perceived motivation. Statistical analyses were conducted to identify if there is effect in students perceived motivation score on the ROMAAD application. In this research, students' perceived motivation of the ROMAAD application was measured by using Keller's Instructional Material Motivational Scale (1993). There were 36 items on this survey form with response scale ranges. This indicates that there is a minimum score of 36 and a maximum score of 180 for the 36-item survey. Each subscale has a different minimum and maximum due to the fact that they don't all have the same amount of items. To determine the average mean score for each question based on the majority scale, a different scoring technique was used for this study. This converts the total into a score ranging from 1 to 5 and makes it easier to clarify the range based on the total. This is due to the fact that the participants transferred their opinions to a scale of 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (strongly agree) in response to 36 statements that were framed both positively and negatively. ince high scores signify good motivation and low scores denote negative motivation, the data analysis for this study inverted the values of negatively expressed items. Table 5.10 presents the findings of the descriptive statistical analysis of the students' perceived motivation of the ROMAAD application. Illustration of perceived motivation on experimental group as below.

Table 5.10

Perceived motivation analysis on experimental group

Dependent Variable	Perceived Motivation
Group	Experimental
***n**	175
Minimum	1
Maximum	5
Mean	4.8
Std. Deviation	0.584
Std. Error Mean	0.098

*n denotes number of students

The descriptive statistical analysis shows the minimum (1) and maximum (5) score for student's perceived motivation on using ROMAAD. Mean scores for perceived motivation on using ROMAAD application is 4.8 with standard deviation of 0.584 (X = 4.8, SD = 0.584). This indicate that the students have a higher perceived motivation towards ROMAAD application as the score is 4.8 which is nearest to the maximum score on perceived motivation. This shows that the students perceived ROMAAD application is motivating. To further conclude the statistical analysis to investigate the hypothesis, detailed analysis was done to provide insights based on the ARCS elements model. The scoring scale was analyzed and categorized based on the ARCS elements which is attention, relevance, confidence and satisfaction.

Table 5.11

Summary of score based on the ARCS elements

ARCS Element	Mean	Std. Deviation	Total (Question)
Attention	*4.9*	0.507	12
Relevance	*4.8*	0.629	9
Confidence	*4.9*	0.584	9
Satisfaction	*5*	0.524	5

From the above result it is evident that the students answered all the question positively as all the mean score is near to the maximum score of 5. The students affirmed that the instructional approach successfully retained their attention, indicating that the application is adept at delivering knowledge in an engaging and immersive manner. Moreover, the applications teaching methods are captivating and interesting enough to hold the users' interest throughout the entire lesson this has the potential to enhance the retention and improvement on the problem-solving skills.

The result proves it on the relevance elements as the students are able to perceive the correlation between the game app and their pre-existing knowledge, it indicates that the application is effectively facilitating their learning process and aiding in the retention of prior knowledge. (Vidal et al., 2019). From the result it can be claimed that the app has effectively transmitted information and abilities that are pertinent to the subject matter because the respondents have expressed confidence that they would be able to pass an exam on the same subject. Student’s responses were positive as shown above which revealed that the application is effective in providing a sense of accomplishment and able to motivate and engage users to achieve a goal or complete

a task which can lead to increased motivation and engagement. This can be concluded that this can be a positive indicator of the ROMAAD's appeal and potential for success students' perceived motivation for the instructional material. Hence, the hypothesis is rejected.

5.3.4 Testing of Hypothesis H_{06}

H_{06}: *There is no significant interaction of the students' thinking styles on the use of ROMAAD application on student's perceived motivation for the instructional material.*

Hypothesis H_{06} examined the effects the moderator variable on the dependent variable. This hypothesis intended to examine significant interaction of students thinking styles of the on the use of ROMAAD application to improve students' perceived motivation.

Table 5.12

Descriptive statistics analysis for students perceived motivation scores for holistic and analytical thinking style for experimental groups

Thinking Style	*n	Mean	Std. Deviation	Std Error of Mean
Analytical thinking	45	4.85	0.355	0.06
Holistic Thinking	130	4.88	0.40	0.068

*n denotes number of students

The statistical analysis showed perceived motivation score across thinking styles for experimental group. The mean score for holistic and analytical thinking style students is 4.88 and 4.85. This reveals that both holistic thinking style students and analytic thinking style students have same level of perceived motivation on using ROMAAD application.

Prior conducting the inferential statistical analysis, the descriptive statistics of thinking styles vs IMMS (ARCS elements) were calculated.

Table 5.13

Descriptive statistical analysis of thinking style based on IMMS score

Thinking Style	ARCS Element	Mean	Total (Question)
Analytical	Attention	*4.833*	12
	Relevance	*4.777*	9
	Confidence	*4.888*	9
	Satisfaction	*5.000*	5
Holistic	Attention	*4.750*	12
	Relevance	*5.000*	9
	Confidence	*4.888*	9
	Satisfaction	*5.000*	5

The statistical analysis shows detailed score for thinking style based on ARCS elements which reflect the perceived motivation. Based on the table above the students answer, mean score for each of the ARSC elements near to the maximum score *5* regardless of their thinking style. This shows both analytical and holistic thinking style students doesn't have much different in term of their perceived motivation.

To determine the significant interaction of the students' thinking styles on the use of ROMAAD application to improve students' perceived motivation. A paired t-test was conducted.

Table 5.14

Paired T-test for perceived motivation

Variable	Thinking Style	Mean	Std Deviation	Std Error Mean	t	df	Sig. (2-tailed)
IMMS	Holistic - Analytical	0.0285	0.0487	0.0082	0	33	1

The pairwise comparison result shown in table 5.14 the mean for paired difference is 0.0285. On the significant interaction of the students thinking styles on the use of ROMAAD application on the students' perceived motivation, the result revealed that there is no significant interaction as (p=1). Hence H_{06} null hypotheses failed to be rejected. This indicating that the thinking style has no impact on the perceived motivation of students towards use of ROMAAD application on their Mathematics education.

5.4 Summary of Research Findings

The findings that were obtained from the analysis of the mathematics problem-solving skills scores revealed that for ROMAAD had an effect on the Mathematics problem-solving skills. Moreover, the IMMS score the detailed insights shows that ROMAAD has positive effect towards perceived motivation. This was evidenced by the statistical result that showed that students who used ROMAAD obtained higher scores nearest to the maximum score for IMMS In contrast, for moderator variable which is thinking style finding revealed that both holistic and analytics thinking style doesn’t not have any significant interaction on the problem-solving skills and perceived motivation by using ROMAAD.

These finding explained that students benefit in term of improving their problem-solving skills while using ROMAAD. The overall findings are summarized in Table 5.15.

5.5 Summary

This chapter provides details of analysed data and result on the effects of using ROMAAD application on the improvement of students' mathematical problem-solving skills between experimental group & control group and perceived motivation. The significant interaction of moderator variable which is thinking style were also discussed. In addition, this chapter provided an explanation of the research methodology employed during the data analysis, the empirical data collected, and the results obtained from the inferential statistics.

The finding revealed that there is effect on the use of ROMAAD application as it has positive impact on the improvement of students' mathematical problem-solving abilities. Hence, the students in the experimental group exhibited greater improvement compared to those in the control groups. Likewise, regarding perceived motivation, the statistical analysis indicates that the highest level of IMMS score was observed. Furthermore, examining the IMMS elements provided further insights, with most students agreeing that ROMAAD encompasses all the IMMS elements, which has a substantial impact. Regarding the significant interaction between thinking style and both dependent variables, problem-solving skills and perceived motivation, the findings indicate that no significant interaction exists.

The interpretation of the empirical results is covered in the following chapter. Effects of the intervention on thinking style, motivation, and problem-solving skills. Lastly, recommendations for further improvements are also addressed.

Table 5.15

Summary of findings

H_0	Hypothesis	Test of significant	Hypothesis (Reject/Fail Reject)	Descriptive statistics	Findings in Textual Representation
H_{03}	There is no effect of using ROMAAD application on the improvement of students' mathematical problem-solving skills	p = 0.008 (p<.05)	Reject	-	There is effect on the use of ROMAAD application as it has positive impact on the improvement of students' mathematical problem-solving abilities. Hence, it can be concluded that the students in the experimental group exhibited greater improvement compared to those in the control groups
H_{04}	There is no significant interaction of the students thinking styles on the use of ROMAAD application to improve students' problem-solving skills.	p = 0.08 (p<.05)	Fail to Reject	-	Based on the descriptive analysis Holistic thinking style students score higher and improved problem-solving skills compare to analytical thinking style students. However the ANOVA findings recorded that there is no significant interaction of the students thinking style on the

					use of ROMAAD application to improve students' problem-solving skills.
H_{05}	There is no effect of using ROMAAD application on the students' perceived motivation for the instructional material.	-	-	The descriptive statistics shows the highest score of perceived motivation based on IMMS score.	Overall, there is improvement on the students' perceived motivation by using ROMAAD application for the instructional material. The statistical analysis shows that highest level of IMMS score. Moreover, further insights based on IMMS elements revealed that majority of the students agree that ROMAAD contains all the IMMS elements which is very impactful.
H_{06}	There is no significant interaction of the students' thinking styles on the use of ROMAAD application to improve students' perceived motivation for the instructional material.	$p = 1$ ($p<.05$)	Fail to Reject	-	There is no significant interaction in students thinking styles on the use of ROMAAD application to improve students' perceived motivation. However, holistic thinking style students scored slightly higher than analytics thinking style students.

CHAPTER 6

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

6.0 Overview

The main aim of this study was to design and develop an interactive, captivating, engaging and motivating Mobile Game Based Learning (MGBL) application that to improve students' Mathematic problem-solving skills among Year 4 students of different thinking styles. This study also attempted to investigate the effectiveness of ROMAAD on perceived motivation.

There are five sections in this chapter. The theoretical framework for the design and development of the ROMAAD is covered in the first section. The research findings' interpretations based on their empirical analysis are given in the second section. These include the effects of the ROMAAD on Mathematics problem solving skills and perceived motivation, moderated by their thinking styles. These effects were measured through pre and post test score, IMMS and SOHAT. The study's implications are suggested in the third section. Limitations and suggestions for additional research are presented in the fourth part. Finally, the study's conclusion and summary are given at the end.

6.1 Design and Development of ROMAAD

The instructional development model and design strategies, which served as the foundation for ROMAAD's design and development, were its two main guiding principles. These two features are covered in the next subsections.

6.1.1 Design Strategies of ROMAAD

The suitability and feasibility of the theoretical framework supporting the research that drove the design and development of the ROMAAD were demonstrated by the successful creation and effectiveness of the ROMAAD on enhancing students' mathematical problem-solving abilities. Figure 6.1 illustrates the design strategies that incorporate all the theoretical theories and models.

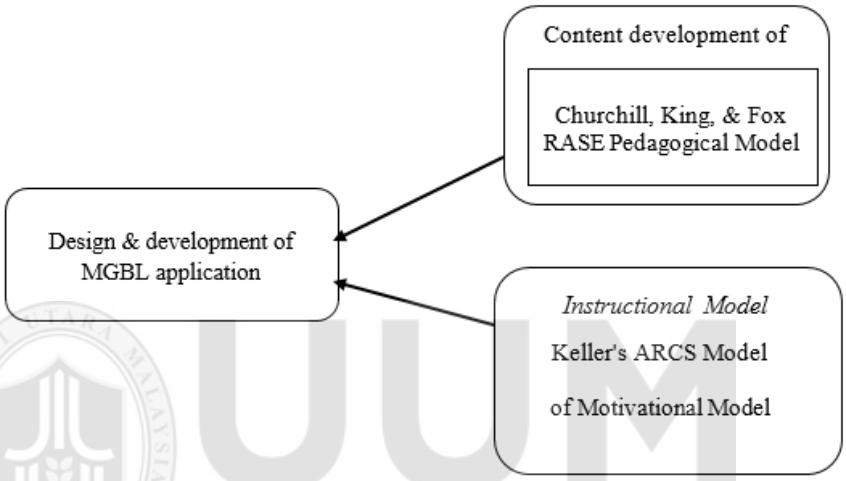


Figure 6.1. Design Strategies of ROMAAD

This intervention was created using the ADDIE approach. The instructional content structure and motivational elements were created using Churchill, King, and Fox's RASE Pedagogical Model and Keller's ARCS Model of Motivational Design from 1987 as the guiding principles. The learning content for the ROMAAD intervention were created using the Malaysia Mathematic Year 4 Syllabus. The design and development of the intervention ROMAAD took place over the course of six months and was divided into three main stages: analysis, design, development, implementation, and evaluation.

These theoretical models were chosen for this study because they were appropriate given the goal of the investigation. The primary goal of this study is to help the students become more proficient at solving mathematical problems, hence the primary content should reflect this goal. A suitable content development model must be used for the creation of the intervention. As a result, a methodology built on problem-solving engagement and learning was applied. It is the RASE Pedagogical Model proposed by Churchill, King, and Fox. The RASE Pedagogical Model was created for a student-centered and authentic curriculum, which is why it was chosen as the pedagogical model. Finding the best ways to use or incorporate technology to enhance student learning and satisfaction is the primary focus of the RASE model approach (Churchill, King & Fox, 2013; Churchill, King, Webster & Fox, 2013).

For this study, an MGBL application which is ROMAAD was developed. ROMAAD Mathematics game learning application which incorporates text, graphics, audio, animations and videos. The ADDIE model, which is structured and programmed with sequences of methodical activities to solve learning difficulties related to learning resources that are following the needs and characteristics of students, served as the foundation for the development of this intervention. The RASE Pedagogical Model was used in ROMAAD development as a content guidance. All the four major contract; recourses, activity, support and evaluation were deployed in ROMAAD creation, as the elements establish for a problem solving and engaged learning intervention. ROMAAD consist of all the elements in the application.

6.1.2 Development of ROMAAD

The fact that ROMAAD's design and development were completed is evidence of the applicability of Florida State University's (1975) ADDIE Instructional Design paradigm, which served as a roadmap for the project. This model consists of five phases: analysis, design, development, implementation, and assessment. The connections between each phase and the others are shown in Figure 6.2.

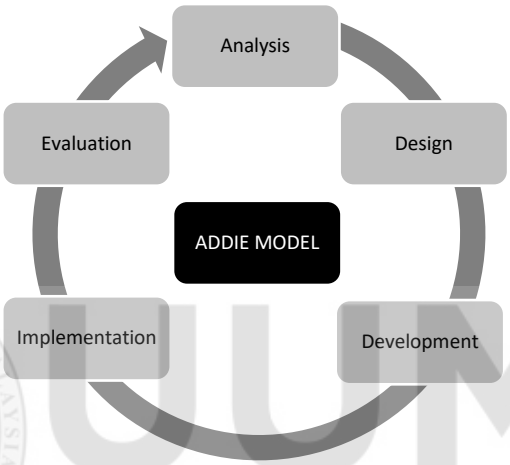


Figure 6.2. ADDIE Instructional Design Model (1975)

One of the systematic learning design methods is the ADDIE instructional design paradigm, which was developed by Florida State University in 1975. The theoretical underpinning of learning design serves as the basis for the methodical development of this model. In an effort to address issues with learning materials that are in line with students' requirements and characteristics. This model has a framework and programming made up of steps for systematic activities. According to Widyastuti (2019), this model is divided into 5 phases: analysis, design, development, implementation, and evaluation.

The first phase in this model is analysis. The analysis phase also refers as the "Goal-Setting Phase." In this phase requirements are obtained and gathered for the development, instructional problems will be clarified, instructional aims and objectives will be established, the learning environment and learners' current knowledge and skills will be identified. In this research, requirement analysis was done, which consist of primary data gathering, secondary data gathering, content analysis and competitive analysis review. Functional requirement, non-functional requirement and use case model was the outcome of the requirement analysis. These three outcomes were then used in design phase.

The second phase is designing the ROMAAD. This phase is crucial for formulating strategies in instructional development, outlining methods to attain teaching objectives, feedback mechanisms, interactivity and usability aspects of the interface (Stapa & Mohammad, 2019). For this research, the concept was transformed into a preliminary form following the analysis of requirements. The ROMAAD content was designed and developed according to the learning objectives and the identification of multimedia elements for the instructional model. The content ideas were created based on well-defined functional and non-functional requirements. The outcome of design phase was a complete storyboard.

The third phase was the development of ROMAAD. The development phase aims to construct the planned structure as per the specifications outlined in the previous two steps. This stage involves the actual construction of the application, incorporating all selected media elements and technologies based on the identified requirements. It builds upon the analysis and design phases (Stapa & Mohammad, 2019). The development phase for this project involves transforming the prototype and

storyboard into an operational system. The content creation process involved utilizing appropriate software to develop multimedia elements, such as functional programs, graphics, text, audio, animations, and video materials. Computer programming was employed to ensure the functionality of the programs, while various multimedia components were integrated to enhance the overall content.

Next phase is implementation phase. The instructional materials have been prepared for utilization or implementation in practical settings. Completed projects will undergo testing with real users and expert review to identify any errors that may have occurred during the development process (Budoya, Kissaka & Mtebe, 2019). In this research, the completed ROMAAD was reviewed by content expert and interface expert.

The evaluation step is the final stage. Formative and summative evaluation are the two components of the evaluation step. To ensure the efficacy of the ADDIE process, formative assessment should be carried out at all levels and covers all of its stages. Conversely, summative assessment concentrates on creating particular assessments that include questionnaires, testing, monitoring, and interviews to get user input on strategies, content, and multimedia components. Summative evaluation usually occurs at the end of a project, following the completion of the creation of instructional materials (Stapa & Mohammad, 2019). In this research in the evaluation phase summative evaluation was carried out the respondents who is Year 4 students to identify the effectiveness of ROMAAD which consist of all usability test terms of use of use, ease of learning, consistency, information structure & design activities and satisfaction.

The ADDIE model's applicability and flexibility in producing learning materials according to requirements justified employing it in the design and development of ROMAAD. ADDIE model frequently serves as the foundation for other instructional design models and teaching approaches. In order to improve the effectiveness and efficiency of the teaching presentation, this model is intended to generate lesson plans and learning resources (Stapa & Mohammad, 2019). The current software development process based on AGILE development as it is a wide umbrella of software development beliefs (Al-Saqqa, Sawalha & AbdelNabi, 2020), ADDIE model was used in in developing an instructional Design developed by Budoya, Kissaka and Mtebe in 2019, which enabled Agile method. Hence, ROMAAD was also developed based on agile development process.

6.2 Discussions of the Research Findings

The sample for this study consisted of 314 Year 4 students from 6 national primary school inclusive of four Sekolah Kebangsaan and two SJK (Tamil). They were divided to two groups which is three school under experimental group who used ROMAAD and another three school under control group. ROMAAD contains all the multimedia elements which is text, graphics, video, audio and animations. These groups were also compared in term of the learning method of Mathematics subject for Year 4 which is effectivess of MGBL application and existing method. The moderator variable was the students' thinking styles which is analytical thinking and holistic thinking.

6.2.1 Effects of ROMAAD on Problem Solving-Skills Improvement

An instructional material was developed based on theoretical framework, namely ROMAAD. ROMAAD was designed according to ADDIE model, Churchill, King & Fox (2013), Resources, Activity, Support, and evaluation (RASE) Pedagogical Model for Integrating Technology, and Keller's ARCS Model of Motivational Design (1987).

Overall, ROMAAD has positive effects in improving Mathematics problem solving skill for the students who was under experimental group. This was evidenced by the statistical result where the post-test obtained higher score than the pre-test. In detail, it was found that students who was under the experimental group scored higher compared to their pre-test score which is prior to utilizing ROMAAD.

This can supported as from a study by Dayo, Asad and Alvi (2021), the Digital Game Based Learning environment is highly effective in fostering a significant growth in students' problem-solving mind set in Mathematics. Hence, the researcher suggested educators and school administrators can utilize these findings to enhance the overall classroom atmosphere for mathematics education. This study supported a finding that was reported by Hafeez (2021) in a literature review of past research indicates that game-based learning has demonstrated remarkable effectiveness as a learning strategy across various disciplines and learning environments. Within the game-based learning approach, learners actively participate and remain highly engaged throughout the learning process and produce effective results.

This study also aligns with study conducted by Brezovszky et al. (2019) on demonstrating the positive impact of a game-based learning environment on the improvement of arithmetic problem-solving abilities. The results emphasized the

effectiveness of this approach in enhancing such skills and highlighted its potential to serve as a practical and adaptable tool for teachers to extend their regular classroom practice. In addition to that, game-based learning also can enhance the problem-solving instincts among the students (Mohanty, Alam, Sarkar & Chaudhury, 2021), which mush require in Mathematics subject.

To conclude, the result on the problem-solving skills improvement in this study showed that the students were able to improve their problem-solving skill. In other words, the major of the students scored higher upon using ROMAAD. This answer the research question 3 which is the effectiveness of the mobile game-based learning application that can improve student's mathematical problem-solving skills.

6.2.2 Effect of ROMAAD on the Students' Perceived Motivation.

ROMAAD was developed based on Keller's ARCS Model of Motivational Design from 1987 as the guiding principles which includes a synthesis of motivational concepts and theories. It consists of all four aspect theories which are attention, relevance, confidence and satisfaction to ensure ROMAAD contains motivation elements in order to have motivation among the students who use it.

From a study carried out by Mohanty, Alam, Sarkar & Chaudhury (2021) the implementation of a Graphical User Interface (GUI) containing engaging and interactive sub-applications resulted in a significant positive transformation in the learning approach of the students. A like in this study ROMAAD also consist of excellent graphical user interface. This can prove through analysis done based on the design of ROMAAD where 93.01% (25.1% agree and 68% strongly agree) students

agreed that this intervention have good graphical user interface which they found it attractive and motivating to continue using it.

Attention is the first requirement, which is related to learning and motivation. Students' attention can be captured via game-based learning settings and watching videos with or without feedback (Velaora, Dimos, Tsagiopoulou & Kakarountas, 2022). Liao, Chen & Shih (2019) conducted research where one of the elements is effect of instructional video within a digital game-based learning environment. The result revealed that the use of instructional videos is an effective way to support learning achievement in the context of DGBL which can influence intrinsic motivation. The ROMAAD game application includes three videos: a storyline video, a tutorial video, and an ending reward video. The storyline video may grab students' interest since it addresses a perceived knowledge gap, and the tutorial video demonstrates how to solve questions. This can be supported by the data where based on the analysis from Keller's survey tool 96.6% students opinion that this game caught their attention in the beginning which ROMAAD will start off with a video storyline.

The second condition, relevance, can come from how things are taught. It might not always originate with the material. According to Velaora, Dimos, Tsagiopoulou, and Kakarountas (2022), an individual will see a course of study as relevant if it provides them with the means to fully fulfill these and other demands. The COVID-19 outbreak prompted an almost unprecedented test of remote education (Sun et al., 2020). Another important area of technology advancement that is not exclusive to the present Industrial Revolution 4.0 is online learning. Online teaching and learning is a useful approach even though teachers and students cannot meet in person

(Verawardina et al., 2020). According to Batubara (2021) the following as features of online learning: the content is presented in text, images, and other multimedia elements that illustrate how the lesson is being taught. In ROMAAD the teaching and learning covers all the multimedia elements (graphic, text, video, animation and audio) This MGBL application will lead to a fun learning experience as expected by young learners and this can be supported by data from Keller's survey tool. 83% students agree that elements in ROMAAD relevance for them and able to keep their attention as well. Positive attitudes are influenced by students' perceptions of the value of educational games as a means of developing their competence. Teachers should be carefull when selecting game elements to ensure that they satisfy the students' requirements for being deemed relevant (Velaora, Dimos, Tsagiopoulou & Kakarountas, 2022).

The third condition is confidence. It is the expectation to succeed. Two of the most used learning outcomes for game-based learning applications are confidence and motivation (Velaora, Dimos, Tsagiopoulou & Kakarountas, 2022). The basic principle of confidence is that motivation is enhanced when students have faith in their ability to complete the assigned material (Keller's, 1987). ROMAAD consist of 18 levels were unlocking each level motivated and made them believe that they have learned and achieved on the topics. This clearly supported by 95% of the students through Keller's survey tool on the levels used in ROMAAD and the feedback upon completion.

The fourth condition, satisfaction, combines research and practice that helps make students feel good about their accomplishments (Velaora, Dimos, Tsagiopoulou & Kakarountas, 2022). One of the Keller's, 1987 strategies is unexpected rewards.

Whenever students anticipate and enjoy the results of a learning task, their motivation to learn is increased (Keller, 1987). According to Alonso-Fernandez et al. (2020), educational games can improve learning outcomes, motivation, and student satisfaction. Results from Kim et al.'s (2018) study on the impact of gamified elements on satisfaction indicate that gamified elements may raise satisfaction levels. In ROMAAD the score for each question, level, and final reward gave them satisfaction feel where they could believe that have learned and revised the mathematics subject where it increased the perceived motivation among the students. This can be substantiated by data from the Keller Survey Tool, which revealed that 100% of students expressed satisfaction upon receiving feedback and rewards.

From this study, the result it is evident that the students answered all the question positively as all the score near to the maximum score 5. The students affirmed that the teaching approach effectively captured their attention suggesting that ROMAAD is skilled, at presenting information in an immersive way. Additionally, the methods used by ROMAAS to teach are captivating enough to keep users interested throughout the lesson. This has the potential to improve retention and enhance problem solving skills. The results support this idea as students were able to recognize the connection, between the game app and what they already knew indicating that it effectively supports their learning process and helps them retain knowledge.

Overall, the result revealed ROMAAD able to increase student’s perceived motivation towards learning. The outcomes indicate that ROMAAD does help transfer relevant material for the topic as the respondents say that they feel confident taking a test about the subject. The above shows student’s positive response to the

application, which confirms its capability of making one feel accomplished, which could increase the user's motivation and engagement. This indicated that the research question (4) four has been answered and described. Which is on student's perceived motivation on the instructional material.

6.2.3 Significant interaction of the students thinking styles on the use of MGBL Application on students' problem-solving skills improvement.

The result of the statistical analysis showed that majority of the students from the total is under holistic thinking category where their ability to view Mathematical problem-solving questions is during providing solutions. Focusing on the experimental group students, even majority of them have holistic thinking approach. In term of percentage holistic thinking style students have improved their problem-solving skill compared to analytical thinking students. The result from the analysis revealed that there was no signification interaction. Both thinking styles, analytical thinking and holistic thinking does not have any interaction and effect on students' problem-solving skills by when using ROMAAD application. Hence, this has answered Research Question (5) five which is on the significant effects of students's thinking style on their mathetical problem solving skills.

6.2.4 Significant Interaction of the Students Thinking Styles on the Use of MGBL Application on Students' Perceived Motivation.

The results of the data analysis for this study indicated that the effects of ROMAAD on students' perceived motivation for the instructional material were not significantly mediated by their thinking style. This indicate that both analytics and holistic thinking style students found ROMAAD as fascinating, motivating, and related to

their ability to their problem-solving skills. This result shows that both analytics and holistic thinking style students preferred game-based learning application that is more motivating and effective compared to existing way of learning. The explanation reveals that Research Question 6 has been addressed and described, which is on the significant effects of the students thinking style on their perceived motivation of the instructional material.

6.3 Implication of Study

The results of this study have significant ramifications for how game-based learning materials are designed to meet the unique needs of students in terms of stimulating and engaging training. As a substitute for existing methods, this study led to the creation of a game-based learning application that helps Year 4 students become more skilled at solving problems in Mathematics questions.

6.3.1 ROMAAD: Engaging Multimedia Elements

The use of various media formats, such as text, graphics, video, and audio, in a single presentation is known as multimedia. Computers, mobile devices, and televisions are just a few examples of the channels via which multimedia material can be transmitted. This content can be interactive or non-interactive. Numerous fields, including education, entertainment, business, and government, use multimedia.

This study defines multimedia as the interactive fusion of various media elements, including text, photos, videos, animations, and music that can be utilized to enhance students' mathematical problem-solving abilities. The core component of ROMAAD is text. It is employed to communicate written information. Text in ROMAAD is additionally utilized to support information found in other media. Music, sound

effects, and videos are all used as audio in ROMAAD. Narration was used for storyline which is in the beginning and end of the game. Music and sound effects were used to gain attention and to increase student's excitement while using the application. In addition, ROMAAD uses graphics to create digital characters and images that enhance the instructional content's attractiveness and engagement. They help to illustrate ideas and attract the students. Video has a significant impact on ROMAAD, increasing students' attention, enjoyment, and guidance. The video provides guidance for the content of the instructional material. In ROMAAD, animation is employed to incorporate interactive features that improve learning by enabling students to enjoy playing the game application. These components are included in the ROMAAD to enable students to actively engage in the gameplay to answer the problem-solving Mathematics questions.

According to Zhang Bowman and Jones (2019) when it comes to multimedia interactivity it is crucial to include feedback and control in addition, to integrating multimedia elements. To keep users engaged and motivated while using any e-learning resource it is important for them to receive feedback on their performance. Immediate feedback is considered the effective as it provides learners with information about both their strengths and areas where they made mistakes. Any delays, in receiving feedback can diminish its significance or relevance (Zhang, Bowman & Jones 2019). In this study ROMAAD provide responses, to the questions. The feedback in term marked them as either correct or incorrect giving student's feedback on the accuracy of their answers and to retry if require target was not achieve by students.

Giving students the power to take control enhances their ability to actively shape their learning experience based on their preferences. When instructional materials only allow engagement learners become observers without active participation, which can ultimately decrease their long-term interest. In ROMAAD students were granted control by having options and pathways to them through navigation tools. For example, the student was given option to select the game play level once the specific levels has been unlocked. They able to select any level based on the preferred chapter they wish to revise.

This study suggests that the use of multimedia components in ROMAAD has a long-lasting effect on students' attention level and levels of game engagement. Moreover, it increases their perceived motivation.

6.3.2 ROMAAD: An Alternative Intervention in Learning, Practicing and improve Mathematics Problem Solving Skills.

This study could be seen as a starting point, in creating recommendations, for using multimedia elements and principles as the pedagogical strategy to improve students Mathematical problem-solving skills. Moreover, developing and producing ROMAAD for Mathematics learning is not costly. Problem solving, in mathematics refers to a student's ability to tackle and solve questions. Various factors such as a student's skills, experiences, background in mathematics, motivation and the structure of the problem itself all play a role, in influencing students approach to problem solving (Yadnya, Ardana & Suharta 2020). In primary school Mathematics has been taught traditionally in classrooms (Lessani, Yunus & Bakar 2017). There are still 21% of primary school students who are still less competent in Mathematics

subjects and 16.87% of students still haven't reached a minimum level in mastering basic knowledge and basic math skills (Petaksiran Sekolah Rendah (KPM), 2019). Furthermore, studies revealed that students were said to struggle with answering Mathematical problems-solving questions (Chinnappan, 2017). As a result, it is important to explore approaches, for learning that can help improve students' problem solving skills in Mathematics (Mustafa et al. 2017). Studies have shown that integrating ICT into Mathematics instruction can increase student's motivation and performance (Zakaria & Khalid 2016). Therefore, learning through digital games would provide an exciting and motivating strategy for solving problem-solving questions (Zeng, Parks & Shang, 2020). ROMAAD was designed and developed to support Year 4 students Mathematical problem-solving skills and their perceived motivation towards Mathematics learning. Problem solving related questions and activities was included in ROMAAD game play as suggested by Nizaruddin et al (2017), on the resolving problem-solving ability of students in mathematics through game-based learning activities, stated that there is an increase in the problem-solving skills and learning outcomes of the students. In this study, the result of problem-solving related questions and activities in the game play revealed that the students were able to improve their Mathematics problem-solving skills. In other words, the designed and developed ROMAAD ia an alternative intervention for learning and practicing Mathematics by Nizaruddin et al (2017).

6.4 Limitations of the Study

Firstly, this study only involved 314 students from Sekolah Kebangsaan (SK) and Sekolah Jenis Kebangsaan Tamil (SJKT). This is due to Sekolah Jenis Kebangsaan Cina (SJKC) does not implement dual-language program for Mathematics subject

during the data collection phase. As a result, the results might not apply to a different setting, such as one with a different social or cultural.

Secondly, ROMAAD was limited to only basic Mathematics skills tutorial which cover the main four basic topics of Mathematics which is addition, subtraction, multiplication and division. Therefore, evalution and findings of effectiveness of tutorial and guidance were not applicable for this study to avoid any data reliability.

Thirdly, this study is limited with number of problem-solving questions as the questions was developed for intermediate levels. Students may have skills of different level e.g., beginners and hard. Hence, they might be a chance for beginner level students to find it difficult to answer or way to easy for heard level students which both level students might show lack of interest.

Lastly, this ROMAAD is only limited to one subject for Year 4 students which is Mathematics and not available for other subject, such as science, language subject and etc. Therefore, the findings of the study were not applicable for overall Mobile Game Based Learning (MGBL) and only applicable for effectiveness of MGBL application for Mathematics subject.

6.5 Recommendations for Future Research

Numerous issues raised by this study require in-depth investigation in future studies. First, future researchers should look into more problem-solving teaching materials or tutorials to be included in the MGBL application based on related framework in an effort to better refine or revise the content and development framework. This will lead to the generation of more independent a self-learning anywhere and anytime.

Second, this study is limitation with number of problem-solving questions as the questions was developed for intermediate levels. For future research, there can be more variety of problem-solving questions to be added each chapter for the students to explore various type of questions.

Third, the sample of the study was limited to only Sekolah Kebangsaan (SK) and Sekolah Jenis Kebangsaan Tamil (SJKT). This is due to Sekolah Jenis Kebangsaan Cina (SJKC) does not implement dual-language program for Mathematics subject during the data collection phase. As such, future researcher could further enhance the application to give language option for the students to choose as per preference. This enhance could further generalize the results to a larger sample to all the school in Malaysia.

Fourthly, in this study there is only one multimedia element was incorporated to provide tutorial for the basic Mathematics skills. Therefore, it is advised that future studies examine the results of adding more multimedia components, including hyperlinks which can link to variety of tutorial video out of the application can also be included in the study.

Lastly, this ROMAAD is only limited to one subject for Year 4 students. This can be improved, expanded to include other subjects and assessed further. This is to collect additional data regarding the efficacy of the ROMAAD MGBL application

6.6 Conclusion

This study proposes a guideline of strategies as in Figure 6.1, for designing and developing a MGBL application (ROMAAD) for improvement of Mathematics problem-solving skills that is engaging, fun and motivating. This study also tested

for the effects of the developed ROMAAD on students' Mathematical problem-solving skills and perceived motivation which resulted in positive effectiveness.

This study supported Byun and Joung (2018) research that digital games (e.g., video games/computer games/mobile games) have been classified as an effective educational method that can increase student motivation and achievement in mathematics education. To experience good Mathematics skills, Mathematics learning has to be incorporated with engaging, fun, pleasure and technology learning environment. Therefore, this study proposed that teaching and learning strategies for Mathematical problem-solving skills for Year 4 students should be improvised as to cater effective learning outcome from the students. Improvising the learning strategies and providing students with supporting self-learning technology such as the use of mobile game-based learning applications, or ROMAADs, will boost students' motivation and willingness to participate in constant, continuous learning.

This study also contributed a positive outcome to Mathematical learning which suggests that Mathematics subject can be thought using multimedia. The multimedia elements embedded in MGBL application content motivated students to practice Mathematics questions, which engages than and subsequently improve their Mathematical problem-solving skills. This is supported by the study's findings, which suggest that ROMAAD has a significant impact on the ability of students to solve Mathematical problems-solving skills. Additionally, the produced ROMAAD is more appealing and interesting, according to this study.

Moreover, this study has added an important expansion to RASE Pedagogical Model by Churchill, King, and Fox (2013) which the main focus of the RASE model is on

how best to use or integrate the technology to boost student learning and satisfaction. The expansion is that adding technology which is MGBL application into Mathematics learning has positive impacts. This study has furnished empirical support for the significance of examining this subtle variance in multimedia learning design with four main elements from RASE model. In this study, incorporation of technology is found to improve the student's attention, engages in learning and motivate them, hence creating effective and Meaningful learning.

The findings of this study revealed that there's an impact on the utilization of the ROMAAD application because it incorporates a positive effect on the advancement of students' Mathematical problem-solving abilities. Furthermore, they can capture their attention, which subsequently elevates their motivation based on other IMMS components which are relevance, confidence and satisfaction.

Overall, this research has led to the creation of the Mobile Game-Based Learning (MGBL) Application (ROMAAD), which focuses on the ideas of multimedia design and aims to increase student's Mathematical problem-solving skills and. students' perceived motivation. Overall, the results of this study indicate that students' ability to solve mathematical problems and their perception of the ROMAAD modes' motivation have significantly improved. When the thinking style were examined as moderator variable on the ROMAAD instruction material, the result showed that there are no any impact as both thinking style students doesn't have much difference in term of their results.

Moreover, this study has resulted in the production of Mobile Game-Based Learning (MGBL) Application (ROMAAD) instructional material that could be used as a

mobile based and standalone portable program to improve Mathematical problem-solving skill and perceived motivation in term from pedagogical strategy. As stated otherwise, the model, theories, and authoring tool utilized in this study were effective in creating captivating and inspiring educational materials that met the study's goals and hypotheses. However, further development and enhancements are required to make this study more dependable and efficient.

In a nutshell, this study has showed that the use of MGBL application, specifically ROMAAD in Mathematics learning, would serve as a useful learning to improve Mathematical problem-solving skills with effective, meaningful and enjoyable learning way. In summary, this study gives timely solutions to help educators create enjoyable, captivating, and inspiring multimedia-based games based on relevant learning theories, which will help students improve other foundational math skills that need to be strengthened.

REFERENCES

Abdullah, A. H., Mokhtar, M., Abd Halim, N. D., Ali, D. F., Tahir, L. M., & Kohar, U. H. A. (2016). Mathematics teachers' level of knowledge and practice on the implementation of higher-order thinking skills (HOTS). *Eurasia Journal of Mathematics, Science and Technology Education, 13*(1), 3-17.

Abdullah, A. H., Rahman, S. N. S. A., & Hamzah, M. H. (2017). Metacognitive skills of malaysian students in non-routine mathematical problem solving. *Bolema: Boletim de Educação Matemática, 31(57), 310-322*.

Abdullah, N., Halim, L., & Zakaria, E. (2014). VStops: A thinking strategy and visual representation approach in mathematical word problem solving toward enhancing STEM literacy. *Eurasia Journal of Mathematics, Science and Technology Education, 10*(3), 165-174.

Acharya, B. R. (2017). Factors affecting difficulties in learning mathematics by mathematics learners. *International Journal of Elementary Education, 6*(2), 8-15.

Ahmad, A. (2019). Applications of Mathematics in Everyday Life.

Al-Azawi, R., Al-Faliti, F., & Al-Blushi, M. (2016). Educational gamification vs. game based learning: Comparative study. *International Journal of Innovation, Management and Technology, 7*(4), 132-136.

Alhassora, N. S. A., Abu, M. S., & Abdullah, A. H. (2017). Inculcating higher-order thinking skills in mathematics: Why is it so hard. *Man in India, 97*(13), 51-62.

Alkhateeb, M. A. (2019). Teachers' beliefs about the nature, teaching and learning of mathematics and sources of these beliefs. *International Journal of Learning, Teaching and Educational Research, 18*(11), 329-347.

All, A., Castellar, E. P. N., & Van Looy, J. (2015). Towards a conceptual framework for assessing the effectiveness of digital game-based learning. *Computers & Education, 88,* 29-37.

Al-Saqqa, S., Sawalha, S., & AbdelNabi, H. (2020). Agile software development: Methodologies and trends. *International Journal of Interactive Mobile Technologies, 14*(11).

Amalia, E., Surya, E., & Syahputra, E. (2017). The effectiveness of using problem based learning (PBL) in mathematics problem solving ability for junior high school students. International J*ournal of Advance Research and Innovative Ideas in Education, 3(2),* 3402-3406.

Annamalai, S. (2016). Designing motivating mE-book for polytechnic language classroom using ARCS model. *The European Proceedings of Social & Behavioral Sciences XIV,* 320-326.

Arnab, S., Lim, T., Carvalho, M. B., Bellotti, F., de Freitas, S., Louchart, S., *et al. (2015). Mapping learning and game mechanics for serious games analysis. British Journal of Educational Technology, 46(2),* 391–411

Aron, A., Aron, E. N., & Coups, E. (2009). *Statistics for psychology (5th ed.)*. Upper

Atasoy, E., & Konyalıhatipoğlu, M. E. (2019). Investigation of students' holistic and analytical thinking styles in learning environments assisted with dynamic geometry software. *Egitim ve Bilim*, *44*(199).

Aznar-Díaz, I., Hinojo-Lucena, F. J., Caceres-Reche, M. P., & Romero-Rodríguez, J. M. (2020). Analysis of the determining factors of good teaching practices of mobile learning at the Spanish University. An explanatory model. *Computers & Education*, *159*, 104007.

Batubara, B. M. (2021). The Problems of the World of Education in the Middle of the Covid-19 Pandemic. *Budapest International Research and Critics Institute (BIRCI-Journal): Humanities and Social Sciences*, *4*(1), 450-457.

Braad, E. (2018). Learn-to-learn: game-based learning for metacognition.

Brezovszky, B., McMullen, J., Veermans, K., Hannula-Sormunen, M. M., Rodríguez-Aflecht, G., Pongsakdi, N. & Lehtinen, E. (2019). Effects of a mathematics game-based learning environment on primary school students' adaptive number knowledge. *Computers & Education*, *128*, 63-74.

Budoya, C. M., Kissaka, M. M., & Mtebe, J. S. (2019). Instructional Design Enabled Agile Method Using ADDIE Model and Feature Driven Development Process. *International Journal of Education and Development Using Information and Communication Technology*, *15*(1), n1.

Byun, J., & Joung, E. (2018). Digital game-based learning for K–12 mathematics education: A meta-analysis. *School Science and Mathematics*, *118*(3-4), 113-126.

Camberwell, Victoria, 3124, Australia.

Chang, R. C., & Yang, C. Y. (2016, May). Developing a mobile app for game-based learning in middle school mathematics course. In *2016 International Conference on Applied System Innovation (ICASI)* (pp. 1-2). IEEE.

Chin, W. A., Yahaya, W. A. J. W., & Muniandy, B. (2018). Virtual science laboratory (vislab): The effect of visual signalling principles towards students' perceived motivation. *International Journal of Engineering & Technology*, *7*(30), 289-292.

Chin, W.A. (2017). *The Effects of Using Visual Signaling Principle in A Virtual Reality Environment On Students' Performance, Cognitive Load And Perceived Motivation.* (Unpublished Doctoral Dissertation). Universiti Sains Malaysia, Pulau Pinang, Malaysia.

Chinnappan, M. (2017). Relationship between scientific reasoning skills and mathematics achievement among Malaysian students. *Geografia-Malaysian Journal of Society and Space*, *12*(1).

Churchill, D., King, M., & Fox, B. (2013). Learning design for science education in the 21st century. *Zbornik Instituta za pedagoska istrazivanja*, *45*(2), 404-421.

Darmawan, E. W., & Suparman, S. (2019). Design of Mathematics learning media based on discovery learning to improve problem solving ability. *Indonesian Journal on Learning and Advanced Education (IJOLAE)*, *1*(2), 20-28.

Daud, Rafizah, Zarulrizam Ab Jalil, and M. Noor Fathoni M. Gunawan. "Community college students' perception towards digital learning In Malaysia." *Procedia-Social and Behavioral Sciences* 195 (2015): 1798-1802.

Dayo, N., Asad, M. M., & Alvi, U. (2021). Effects of Digital Game-Based Learning and Traditional Teaching Approaches on Students' Mathematics Problem-Solving

Attitude. In *Innovative education technologies for 21st century teaching and learning* (pp. 101-112). CRC Press.

Dhayanti, D., Johar, R., & Zubainur, C. M. (2018). Improving Students' Critical and Creative Thinking through Realistic Mathematics Education Using Geometer's

Drigas, A. S., & Pappas, M. A. (2015). A review of mobile learning applications for mathematics. *International Journal of Interactive Mobile Technologies*, *9*(3).

Dunlap, J. C., & Grabinger, R. S. (1996). Rich environments for active learning in the higher education classroom. *Constructivist learning environments: Case studies in instructional design*, 65-82.

Duque Jr, C. A., & Tan, D. A. (2018). Students'mathematics Attitudes And Metacognitive Processes In Mathematical Problem Solving. *European Journal of Education Studies*.

Dziedzic, D. (2016). Use of the Free to Play model in games with a purpose: the RoboCorp game case study. *Bio-Algorithms and Med-Systems*, *12*(4), 187-197.

Educational and Psychological Measurement 1970. 30:607-610.

Elmunsyah, H., Kusumo, G. R., Pujianto, U., & Prasetya, D. D. (2018, October). Development of Mobile Based Educational Game as a Learning Media for Basic Programming in VHS. In *2018 5th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI)* (pp. 416-420). IEEE.

Eltahir, M. E., Alsalhi, N. R., Al-Qatawneh, S., AlQudah, H. A., & Jaradat, M. (2021). The impact of game-based learning (GBL) on students' motivation, engagement and

academic performance on an Arabic language grammar course in higher education. *Education and Information Technologies*, *26*(3), 3251-3278.

Faulkner, F., Breen, C., Prendergast, M., & Carr, M. (2021). Profiling mathematical procedural and problem-solving skills of undergraduate students following a new mathematics curriculum. *International Journal of Mathematical Education in Science and Technology*, 1-30.

Fauzi, M. N., Usodo, B., & Subanti, S. (2017). The comparison of learning model viewed from the students thinking style. *Journal of Education and Learning*, *11*(4), 327-331.

Figueiredo, M., Godejord, B., Rodrigues, J., & Gozáles-Pérez, A. (2016). Milage app: mobile learning of mathematics. *In 8th International Conference on Education and New Learning Technologies (pp. 8863-8872).*

Figueroa-Flores, J. F. (2016). Gamification and game-based learning: Two strategies for the 21st century learner. *World*, *3*(2).

Firdaus, F. M. (2017). Improving Primary Students' Mathematical Literacy through Problem Based Learning and Direct Instruction. *Educational Research and Reviews*, *12*(4), 212-219.

Fitzpatrick, L. P., & Sovde, D. (2019). The case for mathematics pathways from the launch years in high school through postsecondary education. *Emerging issues in mathematics pathways*, 97-104.

Guinungco, H., & Roman, A. (2020). Abstract Reasoning and Problem-Solving Skills of First Year College Students. *Southeast Asian Journal of Science and Technology*, *5*(1), 33-39.

Gunawan, T. S., Bahari, B., & Kartiwi, M. (2017). Development of educational game for primary school mathematics using microsoft kinect. *Indones J Electr Eng Comput Sci*, *6*(2), 457-463.

Hafeez, M. (2021). Effects of Game Based Learning in Comparison of Traditional Learning to Provide Effective Learning Environment-A Comparative Review. *International Journal of Social Sciences & Educational Studies*, *8*(4), 100.

Halloluwa, T., Vyas, D., Usoof, H., & Hewagamage, K. P. (2018). Gamification for development: a case of collaborative learning in Sri Lankan primary schools. *Personal and Ubiquitous Computing, 22*(2), 391-407.

Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016). Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. *Computers in human behavior, 54*, 170-179.

Handican, R., & Setyaningrum, W. (2021). Developing a Mobile Game Using Scientific Approach to Support Mathematics Learning. *Edumatika: Jurnal Riset Pendidikan Matematika*, *4*(1), 47-58.

HAO, S. L., & Liu, Z. C. (2019). How to Raise the Quality of Higher Mathematics Teaching in the Economics and Management Disciplines Under Idea of General Education.

Harandi, S. R. (2015). Effects of e-learning on Students' Motivation. *Procedia-Social and Behavioral Sciences, 181*, 423-430.

Hashim, S. H. M., Hashim, S., & Ahmad, T. B. T. (2019). Using Educational Game Apps In Improving Students Mathematics'learning: An Exploratory Study On Third Grader At-Risk Classroom At Primary School In Selangor, Malaysia. *Int. J. Educ. Res*, *7*(5), 253-264.

Hassan, N. M., & Rahman, S. (2017). Problem solving skills, metacognitive awareness, and mathematics achievement: A mediation model. *The New Educational Review*, *49*(3), 201-212.

Hou, H. T., & Li, M. C. (2014). Evaluating multiple aspects of a digital educational problem-solving-based adventure game. *Computers in Human Behavior*, *30*, 29-38.

Howard-Jones, P. A., & Jay, T. (2016). Reward, learning and games. *Current opinion in behavioral sciences*, *10*, 65-72.

Huang, R., & Burgos, D. (2020). The Evolution of Educational Game Designs From Computers to Mobile. *Radical Solutions and eLearning: Practical Innovations and Online Educational Technology*, 81.

Huang, S. Y., Kuo, Y. H., & Chen, H. C. (2020). Applying digital escape rooms infused with science teaching in elementary school: Learning performance, learning motivation, and problem-solving ability. *Thinking Skills and Creativity*, *37*, 100681.

Huincahue, J., Borromeo-Ferri, R., Reyes-Santander, P., & Garrido-Véliz, V. (2021). Mathematical Thinking Styles—The Advantage of Analytic Thinkers When Learning Mathematics. *Education Sciences*, *11*(6), 289.

Huizenga, J., Admiraal, W., Ten Dam, G., & Voogt, J. (2019). Mobile game-based learning in secondary education: Students' immersion, game activities, team performance and learning outcomes. *Computers in Human Behavior, 99*, 137-143.

Hussain, S. Y. S., Tan, W. H., & Idris, M. Z. (2014). Digital game-based learning for remedial mathematics students: A new teaching and learning approach in Malaysia. *International Journal of Multimedia Ubiquitous Engineering*, *9*(11), 325-338.

Hwa, S. P. (2018). Pedagogical change in mathematics learning: Harnessing the power of digital game-based learning. *Journal of Educational Technology & Society*, *21*(4), 259-276.

İncebacak, B. B., & Ersoy, E. (2016). Problem solving skills of secondary school students. *China-USA Business Review*, *15*(6), 275-285.

Ing, M., Webb, N. M., Franke, M. L., Turrou, A. C., Wong, J., Shin, N., & Fernandez, C. H. (2015). Student participation in elementary mathematics classrooms: the missing link between teacher practices and student achievement?. *Educational Studies in Mathematics*, *90*(3), 341-356.

Ismail, I., Azizan, S. N., & Azman, N. (2013). Mobile Phone as Pedagogical Tools: Are Teachers Ready?. *International Education Studies*, *6*(3), 36-47.

Isyrofinnisak, F., Kusmayadi, T. A., & Fitriana, L. (2020, May). Mathematics creativity skill of student in junior high school based on students thinking style. In *Journal of Physics: Conference Series* (Vol. 1538, No. 1, p. 012068). IOP Publishing.

Jeno, L. M., Adachi, P. J., Grytnes, J. A., Vandvik, V., & Deci, E. L. (2019). The effects of m-learning on motivation, achievement and well-being: A Self-Determination Theory approach. *British Journal of Educational Technology*, *50*(2), 669-683.

Jonassen, D. H. (2000). Toward a design theory of problem solving. *Educational technology research and development*, *48*(4), 63-85.

Jossan, K. S., Gauthier, A., & Jenkinson, J. (2021). Cultural implications in the acceptability of game-based learning. *Computers & Education*, *174*, 104305.

Kayali, S., & Yilmaz, M. (2017). An exploratory study to assess analytical and logical thinking skills of the software practitioners using a gamification perspective. *Suleyman Demirel Universitesi Fen Bilimleri Enstitusu Dergisi, 21(1)*, 178-189.

Khalid, M. (2017). Fostering problem solving and performance assessment among Malaysian

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and psychological measurement*, *30*(3), 607-610.

Krishnasamy, S., Ling, L., & Kim, T. (2020). Improving learning experience of probability and statistics using multimedia system. *International Journal of Emerging Technologies in Learning (iJET)*, *15*(1), 77-87.

Lessani, A., Yunus, A., & Bakar, K. (2017). Comparison of new mathematics teaching methods with traditional method. *People: International Journal of Social Sciences*, *3*(2), 1285-1297.

Liao, C. W., Chen, C. H., & Shih, S. J. (2019). The interactivity of video and collaboration for learning achievement, intrinsic motivation, cognitive load, and behavior patterns in a digital game-based learning environment. *Computers & Education*, *133*, 43-55.

Ling, L. T. Y. (2018). Meaningful Gamification and Students' Motivation: A Strategy for Scaffolding Reading Material. *Online Learning*, *22*(2), 141-155.

Liu, Z. Y., Shaikh, Z., & Gazizova, F. (2020). Using the concept of game-based learning in education. *International Journal of Emerging Technologies in Learning (iJET)*, *15*(14), 53-64.

Maass, K., Geiger, V., Ariza, M. R., & Goos, M. (2019). The role of mathematics in interdisciplinary STEM education. *ZDM*, *51*(6), 869-884.

Mahat, J., Ayub, A. F. M., & Luan, S. (2012). An assessment of students' mobile self-efficacy, readiness and personal innovativeness towards mobile learning in higher education in Malaysia. *Procedia-Social and Behavioral Sciences*, *64*, 284-290.

Mahmoudi, G. R., Javadi, M., & Sahraee, M. (2013). The Relationship Between Thinking Styles And Personality Types And Achievement Motivation In Guidance School Students.

Masrom, M., Nadzari, A. S., & Zakaria, S. A. (2016). Implementation of Mobile Learning Apps in Malaysia Higher Education Institutions. *E-Proceeding of the 4th Global Summit on Education, 268-76.*

Masrom, M., Nadzari, A. S., Mahmood, N. H. N., Zakaria, W. N. W., & Ali, N. R. M. (2016). Mobile learning in Malaysia education institutions. *Issues in Information Systems*, *17*(4), 152-157.

McCormick, N. J., Clark, L. M., & Raines, J. M. (2015). Engaging students in critical thinking and problem solving: A brief review of the literature. *Journal of Studies in Education*, *5*(4), 100- 113.

McKenna, H. P., Arnone, M. P., Kaarst-Brown, M. L., McKnight, L. W., & Chauncey, S. A. (2013, July). Ambient and emergent learning with wireless grid technologies. In *Proceedings of the 5th Intl Conf on Educ. & New Learning Technologies (EduLearn13)* (pp. 2-3).

Mivehchi, L., & Rajabion, L. (2020). A framework for evaluating the impact of mobile games, technological innovation and collaborative learning on students' motivation. *Human Systems Management*, *39*(1), 27-36.

Mohanty, A., Alam, A., Sarkar, R., & Chaudhury, S. (2021). Design and Development of Digital Game-Based Learning Software for Incorporation into School Syllabus and Curriculum Transaction. *Design Engineering*, *8*, 4864-4900

Mokhtar, M. A. M., Ayub, A. F. M., Radhiah, R., & Said, S. S. M. (2019). Analysis of Year Four Pupils' Difficulties in Solving Mathematical Problems Involving Fraction. *International Journal Of Academic Research In Business And Social Sciences, 9(11).*

Murphy, M. (2016). *Population definitions for comparative surveys in education.*

Mustafa, N., Said, M. N. H. M., Ismail, Z., & Tasir, Z. (2017). Mathematical Problem Solving Skills among High Achiever Students. *Advanced Science Letters, 23(8),* 7494-7498.

Nakhaei, S., Amiri Majd, M., Mohamadi Arya, A. R., & Shiraz, M. (2018). Presenting a Model for Explanation of the Relationship of Students' Internal Motivaltion with Teacher Demographic Characteristics: Mediating Role of Learning Styles, Thinking Styles. *Education Strategies in Medical Sciences*, *11*(2), 106-114.

Nasukhah, N. (2020). The Relationship Between Students'language Learning Strategies And Their Thinking Styles Use. *Jurnal Penelitian, Pendidikan, dan Pembelajaran*, *15*(28).

Navarrete, C. C. (2013). Creative thinking in digital game design and development: A case study. *Computers & Education*, *69*, 320-331.

Nezu, A. M., & Nezu, C. M. (2016). Problem solving.

Nikou, S. A., & Economides, A. A. (2016). The impact of paper-based, computer-based and mobile-based self-assessment on students' science motivation and achievement. *Computers in Human Behavior*, *55*, 1241-1248.

Nizaruddin, N., Muhtarom, M., & Sugiyanti, S. (2017). Improving students' problem-solving ability in mathematics through game-based learning activities.

Novriani, M. R., & Surya, E. (2017). Analysis of student difficulties in mathematics problem solving ability at MTs SWASTA IRA Medan. *International Journal of Sciences: Basic and Applied Research (IJSBAR)*, *33*(3), 63-75.

Nunes, T., Dorneles, B. V., Lin, P. J., & Rathgeb-Schnierer, E. (2016). *Teaching and learning about whole numbers in primary school*. Springer Nature.

Offenholley, K. H. (2012). Gaming your mathematics course: The theory and practice of games for learning. *Journal of Humanistic Mathematics*, *2*(2), 79-92.

Papadakis, S. (2018). Evaluating pre-service teachers' acceptance of mobile devices with regards to their age and gender: a case study in Greece. *International Journal of Mobile Learning and Organisation*, *12*(4), 336-352.

Partovi, T., & Razavi, M. R. (2019). The effect of game-based learning on academic achievement motivation of elementary school students. *Learning and Motivation*, *68*, 101592.

People, N. A. Y. 'Laying the Foundations': Irish Early Years Practitioners' Perspectives on the Importance of Mathematics in Early Childhood By Cora Gillic.

Pimta, S., Tayraukham, S., & Nuangchalerm, P. (2009). Factors Influencing Mathematic Problem-Solving Ability of Sixth Grade Students. *Online Submission*, *5*(4), 381-385.

Qasim, M. M., Khalaf, H. S., Abdulkareem, A. R., & Yussop, Y. M. (2018). Design and Development of an Interactive Persuasive Mathematics Game for Primary School Children. *International Journal of Engineering & Technology*, *7*(4.19), 272-276.

Qian, M., & Clark, K. R. (2016). Game-based Learning and 21st century skills: A review of recent research. *Computers in Human Behavior*, *63*, 50-58.

Rahman, A., & Ahmar, A. (2016). Exploration of mathematics problem solving process based on the thinking level of students in junior high school. *International Journal of Environmental and Science Education*, *11*(14).

Rahmy, S. N., Usodo, B., & Slamet, I. (2019, March). Mathematics communication skill of student in junior high school based on students thinking style. In *Journal of Physics: Conference Series* (Vol. 1188, No. 1, p. 012107). IOP Publishing.

Rani, P & Agarwal,N . (2020). Thinking Styles: An Overview. 10.5281/zenodo.3837701.

Ratheeswari, K. (2018). Information communication technology in education. *Journal of Applied and Advanced research*, *3*(1), 45-47.

Riding, R., & Cheema, I. (1991). Cognitive styles—an overview and integration. *Educational psychology*, *11*(3-4), 193-215.

Saddle River, NJ: Pearson.

Samur, Y. (2019). Kes Sesi: A mobile game designed to improve kindergarteners' recognition of letter sounds. *Journal of Computer Assisted Learning*, *35*(2), 294-304.

Saward, V. (2017). Mathematics delivering the advantage: the role of mathematicians in manufacturing and beyond. *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *473*(2201), 20170094.

Setyaningrum, W., Pratama, L. D., & Ali, M. B. (2018). Game-based learning in problem solving method: The effects on students' achievement. *International Journal on Emerging Mathematics Education*, *2*(2), 157-164.

Shahali, E. H. M., Ismail, I., & Halim, L. (2017). STEM education in Malaysia: Policy, trajectories and initiatives. *Asian Research Policy*, *8*(2), 122-133.

Shukri, M. R. M., & Ariffin, S. A. (2019). The Development Process of Awang Sains 2D Digital Mobile Game. *Journal of ICT in Education*, *6*, 28-36.

Shukri, M. R. M., & Ariffin, S. A. (2020, October). Evaluation of Mobile Game Based Learning Heuristic Using Fuzzy Delphi Technique for Primary School Science Subject in Malaysia. In *World Conference on Mobile and Contextual Learning* (pp. 105-110).

Shute, V. J., & Emihovich, B. (2018). Assessing problem-solving skills in game-based immersive environments. *Second Handbook ofInformation Technology in Primary and Secondary Education*, 635-648.

Simamora, R. E., Sidabutar, D. R., & Surya, E. (2017). Improving learning activity and students' problem solving skill through problem based learning (PBL) in junior high school. *International Journal of Sciences: Basic and Applied Research (IJSBAR)*, *33*(2), 321-331.

Sketchpad. *Journal of Research and Advances in Mathematics Education*, *3*(1), 25-35.

Sodiqovich, U. M., Burxonovich, A. X., & Mamarasulovich, S. B. (2020). Interactive E-Learning Courses as a New Teaching Method. *Academia Open*, *2*, 10-21070.

Solso, R. L, Maclin, O, & Maclin, M. K. 2007. Cognitive Psychology. Dalam Rahardanto, M & Batuadji, K. Psikologi Kognitif Edisi Kedelapan. Jakarta: Erlangga

Stapa, M. A., & Mohammad, N. A. Z. E. R. I. (2019). The use of Addie model for designing blended learning application at vocational colleges in Malaysia. *Asia-Pacific Journal of Information Technology and Multimedia*, *8*(1), 49-62.

Sternberg, R. J. (1997). The concept of intelligence and its role in lifelong learning and success. *American psychologist*, *52*(10), 1030.

Sternberg, R. J., & Grigorenko, E. L. (2001). Unified psychology.

Stoyanova, M., Tuparova, D., & Samardzhiev, K. (2016, September). Gamification in 11th grade mathematics lessons–One possible interactive approach. In *International Conference on Interactive Collaborative Learning* (pp. 41-53). Springer, Cham.

Sung, H. Y., Hwang, G. J., Lin, C. J., & Hong, T. W. (2017). Experiencing the Analects of Confucius: An experiential game-based learning approach to promoting students' motivation and conception of learning. *Computers & Education*, *110*, 143-153.

Surya, E., & Putri, F. A. (2017). Improving mathematical problem-solving ability and self-confidence of high school students through contextual learning model. *Journal on Mathematics Education*, *8*(1), 85-94.

Suseelan, M., Chew, C. M., & Chin, H. (2023). School-type difference among rural grade four Malaysian students' performance in solving mathematics word problems involving higher order thinking skills. *International Journal of Science and Mathematics Education*, *21*(1), 49-69.

Taherdoost, H. (2016). Sampling methods in research methodology; how to choose a sampling technique for research. *How to Choose a Sampling Technique for Research (April 10, 2016)*.

The Australian Council for Educational Research Ltd 19 Prospect Hill Road,

Tokac, U., Novak, E., & Thompson, C. G. (2019). Effects of game-based learning on students' mathematics achievement: A meta-analysis. *Journal of Computer Assisted Learning*, *35*(3), 407-420.

Ulandari, L., Amry, Z., & Saragih, S. (2019). Development of Learning Materials Based on Realistic Mathematics Education Approach to Improve Students' Mathematical Problem Solving Ability and Self-Efficacy. *International Electronic Journal of Mathematics Education*, *14*(2), 375-383.

Umay, A., & Ariol, Ş. (2011). Baskın Olarak Bütüncül Stilde Düşünenlerle Baskın Olarak Analitik Stilde Düşünenlerin Problem Çözme Davranışlarının Karşılaştırılması. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi*, (30), 27-37.

Upu, H., & Sulfianti, A. (2018, June). The profile of students' mathematical problem solving on the topic of two-variable linear equation systems based on thinking styles. In *Journal of Physics: Conference Series* (Vol. 1028, No. 1, p. 012164). IOP Publishing.

Utami, L. F., Pramudya, I., & Slamet, I. (2020). Students' Mathematical Communication Skills in Terms of Concrete and Abstract Sequential Thinking Styles. *Al-Jabar: Jurnal Pendidikan Matematika*, *11*(2), 371-381.

Varisoglu, B. (2018). Motivation to learn Turkish in foreign students with different thinking styles in terms of functional and formal aspects. *Educational Research and Reviews*, *13*(9), 328-335.

Velaora, C., Dimos, I., Tsagiopoulou, S., & Kakarountas, A. (2022). A game-based learning approach in digital design course to enhance students' competency. *Information*, *13*(4), 177.

Vicziany, M., & Puteh, M. (2004, June). Vision 2020, the multimedia supercorridor and Malaysian universities. In *15th Biennial Conference of the Asian Studies Association of Australia* (Vol. 29). Asian Studies Association of Australia.

Vlachopoulos, D., & Makri, A. (2017). The effect of games and simulations on higher education: a systematic literature review. *International Journal of Educational Technology in Higher Education*, *14*(1), 1-33.

Widana, I. W., Sumandya, I. W., Sukendra, I. K., & Sudiarsa, I. W. (2020). Analysis of conceptual understanding, digital literacy, motivation, divergent of thinking, and creativity on the teachers skills in preparing hots-based assessments. *Journal of Advance Research in Dynamical & Control Systems*, *12*(8), 459-466.

Widodo, S. A., & Ikhwanudin, T. (2018). Improving mathematical problem solving skills through visual media. In *Journal of Physics: Conference Series* (Vol. 948, No. 1, p. 012004). IOP Publishing.

Wu, T. T. (2018). Improving the effectiveness of English vocabulary review by integrating ARCS with mobile game-based learning. *Journal of Computer Assisted Learning*, *34*(3), 315-323.

Yadnya, N. W. A. W., Ardana, I. M., & Suharta, I. G. P. (2020, July). Development of Mathematics Learning Device Based on Cooperative Model Type of Think Talk Write that Supported by Edmodo for Developing the Mathematics Problem Solving Skills. In *Journal of Physics: Conference Series* (Vol. 1503, No. 1, p. 012012). IOP Publishing.

Yagci, M. (2016). Blended Learning Experience in a Programming Language Course and the Effect of the Thinking Styles of the Students on Success and Motivation. *Turkish Online Journal of Educational Technology-TOJET*, *15*(4), 32- 45.

Yu, K. C., Fan, S. C., & Lin, K. Y. (2015). Enhancing Students'problem-Solving Skills Through Context-Based Learning. *International Journal of Science and Mathematics Education*, *13*(6), 1377-1401.

Zakaria, N. A., & Khalid, F. (2016). The benefits and constraints of the use of information and communication technology (ICT) in teaching mathematics. *Creative Education*, *7*(11), 1537-1544.

Zeng, J., Parks, S., & Shang, J. (2020). To learn scientifically, effectively, and enjoyably: A review of educational games. *Human Behavior and Emerging Technologies*, *2*(2), 186-195.

Zhang, L. F., & Sternberg, R. J. (2000). Are learning approaches and thinking styles related? A study in two Chinese populations. *The Journal of psychology*, *134*(5), 469-489.

Zhang, L., Bowman, D. A., & Jones, C. N. (2019, September). Exploring effects of interactivity on learning with interactive storytelling in immersive virtual reality. In *2019 11th International Conference on Virtual Worlds and Games for Serious Applications (VS-Games)* (pp. 1-8). IEEE.

APPENDICES

Appendix A

(Permission for data collection)

AWANG HAD SALLEH
GRADUATE SCHOOL OF ARTS AND SCIENCES
UUM College of Arts and Sciences
Universiti Utara Malaysia
06010 UUM SINTOK
KEDAH DARUL AMAN
MALAYSIA

UUM
Universiti Utara Malaysia

Tel : 604-928 [illegible]
Faks (Fax): 604-928 5297
Laman Web (Web): http://ahsgs.uum.edu.my
Email : ahsgsservices@uum.edu.my

Our Ref. : UUM/CAS/AHSGS/826641

Date : 20 June 2022

TO WHOM IT MAY CONCERN

Dear Sir/Madam

DATA COLLECTION FOR PROJECT PAPER/THESIS

This is to certify that the following student is currently conducting a field study and data collection as partial requirements of the graduate studies:

Name	:	**Azmath Begam binti Abdul Aziz**
Matric No.	:	**826641**
Course	:	**Master of Science (Multimedia Studies)**
Thesis Title	:	**Effectiveness of Mobile Game Based Learning to Improve Mathematical Problem Solving and Perceived Motivation among Primary Students of Different Thinking Styles**

For further information regarding the research work of the project paper/thesis, **you may get in touch with Ts. Dr. Subashini a/p Annamalai, the supervisor at +6 019-412 1242 or email to subashini@uum.edu.my.**

We sincerely hope your organisation will be able to assist the student for the data collection process.

Thank you

"WAWASAN KEMAKMURAN BERSAMA 2030"
"BERKHIDMAT UNTUK NEGARA"
"KEDAH SEJAHTERA - NIKMAT UNTUK SEMUA"
"ILMU BUDI BAKTI"

Upholding the principles of trust and integrity

SURAYA BINTI DERAMAN
Senior Principal Assistant Registrar
p.p. Dean

Appendix B

(Pre-test & Post Test)

SCHOOL OF MULTIMEDIA TECHNOLOGY AND COMMUNICATION

UNIVERSITI UTARA MALAYSIA

KEDAH DARUL AMAN

This question paper is to test on the student level of understanding in problem solving question in Mathematics.

Instruction:

This paper consist of 15 question. Please read each question carefully and answer accordingly.

Name: ……

School: ……

** All the information that will be provided by the students in this questionnaire will be anonymous and confidential.*

1. 46713 + 13456

2. Find the product of 3 620 and 16

3. Round off 58 477 to the nearest thousand.

4. 63 247 – 10 126

5. 15150 ÷ 5

6. What is the place value of digit 8 in 84 172?

7. 4 217-1 098+ 866

8. (a) $\frac{1}{4} + \frac{3}{8} =$

(b) $\frac{2}{3} + \frac{1}{6} =$

9. How many need to be added to 15.5 to make it 40.

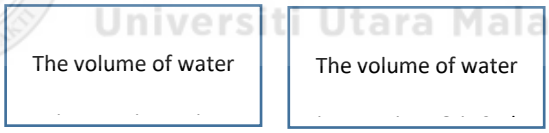
10. Ram and his family went for a vacation for 108 hours. Calculate the **total days** and **hours** of the vacation.

11. An NGO allocated RM 7500 for an education programme. The money distributed equally to 6 school. How much money was received by 4 school?

12. State 0145 pm in 24 hours system

13. Mrs. Tan has $\frac{1}{5}$ kg of sugar. She buys another $\frac{3}{5}$ kg of sugar. How much sugar does she have altogether?

14 The distance between Ayob house and work place is 6.8 KM. Ayob travels the distance 5 days in a week. Calculate the total distance travelled by Ayob in 3 days.



15. Based on the information above calculate the total volume of water in both container in ml.

Appendix C

(The Scale of Holistic and Analytical Thinking

(SOHAT))

SCHOOL OF MULTIMEDIA TECHNOLOGY AND COMMUNICATION
UNIVERSITI UTARA MALAYSIA
KEDAH DARUL AMAN

PROBLEM SOLVING ANALYTICAL AND HOLISTIC THINKING SCALE

This questionnaire is to identify the students thinking style and method when the students solving a problem. The result from this questionnaire will determine different thinking style of the student while they play a game application on Mathematics.

Instruction:
Everyone has a thinking style. None of these thinking styles is "better" or "worse" than the others. Here, it is tried to determine which thinking style you think more while solving problems. Please **tick (/)** the option closest to you. If you cannot determine how you think, tick the "I don't know how I did it" option. Choose only **ONE** according to your preferences.

Name: .....

School: .....

** All the information that will be provided by the students in this questionnaire will be anonymous and confidential.*

Description	Problem solving method. Choose the best way u will use to solve a problem.		Choose this option if you have no idea how to solve
Method of solving problem	When solving a problem, I use a step-by-step method to identify the problem and find the solution ( )	I often use methods such as guessing, trial and error when solving a problem. ( )	I don't know how I did it ( )
Explaination on how a problem is solved	I usually able to describing how I solved a problem. ( )	I often find it difficult to explain on how I solved the problem. ( )	I don't know how I did it ( )
Construction of solution	When I'm trying to solve the problem, the solution usually pops up in front of my eyes. ( )	While solving the problem, the solution is usually constructed step-by-step ( )	I don't know how I did it ( )
Feelings of accomplishment	I feel that I found the result by chance. ( )	I often feel that I am able to solve any problem concisely ( )	I don't know how I did it ( )
Solution algorithm	I have to follow an algorithm while solving problems. (Algorithm: step-by-step, standard way with clear steps) ( )	While solving problems, I prefer to follow my own ideas. Instead of following a certain algorithm (step-by-step, standard way with clear steps) ( )	I don't know how I did it ( )

Appendix D

(Instructional Materials Motivation Scale

(IMMS))

SCHOOL OF MULTIMEDIA TECHNOLOGY AND COMMUNICATION

UNIVERSITI UTARA MALAYSIA

KEDAH DARUL AMAN

This questionnaire is to investigate the perceived motivation aspect of Mobile Game Based Learning application. The result from this questionnaire will determine if the player have motivated perception while playing the game application and the development of the application has positive impact on the learning of Year 4 primary.

Instruction:

This paper consist of 35 question. Please read each question carefully and select the answer that best represents your opinion on the given scale. Choose only **ONE** according to your preferences.

Name: …….

School: ……

** All the information that will be provided by the students in this questionnaire will be anonymous and confidential.*

1. When I first looked at this game application, I know that it would be easy for me.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

2. There was something interesting at the beginning of this game application that got my attention.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

3. This lesson in game was difficult to understand.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

4. After accessing the how to play information, I know what I will learn from this game application.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

5. Completing the exercises in this game application gave me a feel of accomplishment.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

6. I can understand how the content of this game application is related to things I have already learned.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

7. There are too much information for me to remember in this game application.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

8. This game application is attractive.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

9. The content and elements in this game application is useful for me.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

10. Completing exercise in this game application successfully was important to me.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

11. The quality of the font in the game application helped to hold my attention.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

12. The exercise in the game application is so brief that it was hard to keep my attention on it.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

13. I was confident that I could learn the content in this game.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

14. I enjoyed using this game application so much.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

15. The screen/interface of this game application look dry and unappealing.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

16. The way the lesson was taught on the game application helped keep my attention.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

17. There are tutorials on how to use this game application.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

18. The exercises in this game application were too difficult.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

19. This game application has elements that stimulated my interest.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

20. I really enjoyed playing this game application.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

21. The amount of repetition in this game make me feel bored sometimes.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

22. The content and style of this game convey the impression that its content is worth knowing.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

23. I able to learn unexpected content in this game.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

24. After completing this game, I was confident that I would be able to pass a test on the same topic.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

25. This game was not relevant to my needs because I already knew most of the content.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

26. The feedbacks after each level of the game application, helped me feel rewarded for my effort.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

27. The variety of interface and graphic helped keep my attention on the game application.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

28. The style of fonts used in the game application is attractive.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

29. I could relate the content of this game application to my own learning.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

30. Levels is the game application is irritating.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

31. It felt good to successfully complete this game.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

32. The content of this game application will be useful to me.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

33. I could not really understand the content of this game application.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

34. The good organization of the topic in this game application helped me to be confident that I would learn this lesson.

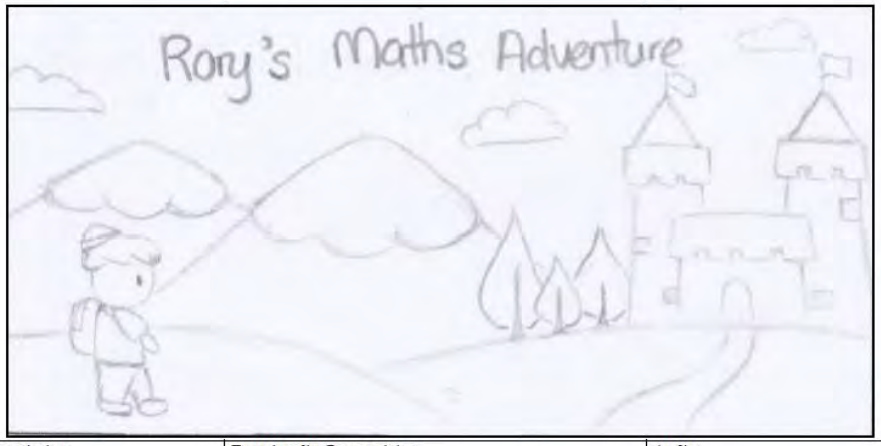
1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

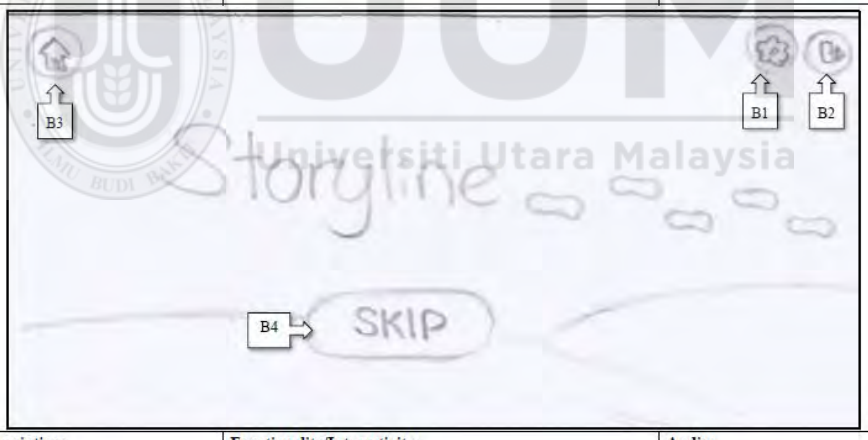
35. It was a pleasure to play a well-designed game application.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
○	○	○	○	○

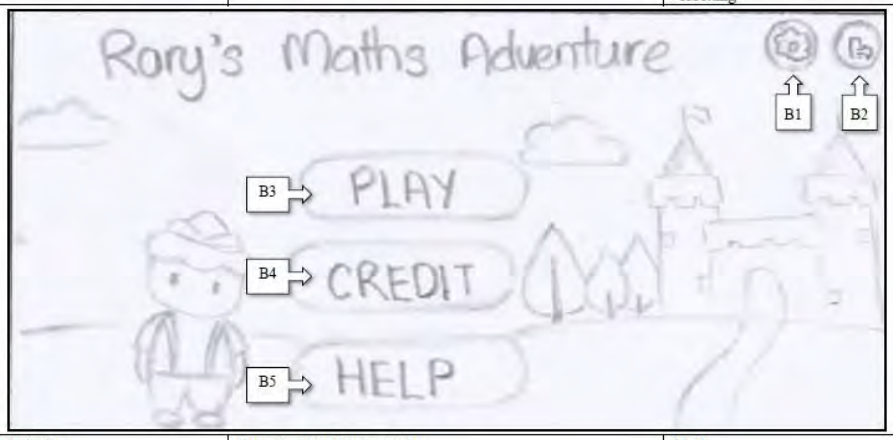
Appendix E

(Storyboard of ROMAAD)

Screen: Screen 1 (Splash Screen)	**Links from screens:** -	**Links to screens:** Main Menu
		
Screen Description:	**Functionality/Interactivity:**	**Audio:**
Splash screen is the first page that will display once the user enter the game.	Loading	Background Music

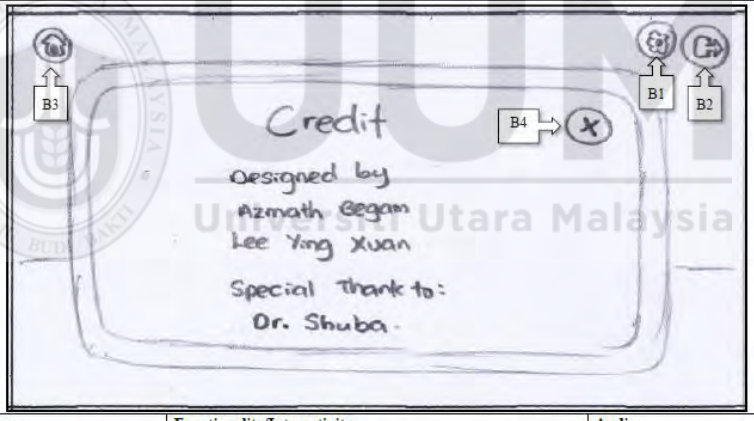
Screen: Screen 2 (Storyline)	**Links from screens:** Splash screen	**Links to screens:** Main Menu
		
Screen Description:	**Functionality/Interactivity:**	**Audio:**
In this screen a short storyline will be played.	B1: Link to setting screen B2: Link to exit screen B3: Link to main menu B4: Link to main Menu	- Background music - button clicking sound - Voice over from the story

Screen: Screen 3 (Main Menu)	**Links from screens:** Storyline	**Links to screens:** Select level, Credit, Exit &Setting



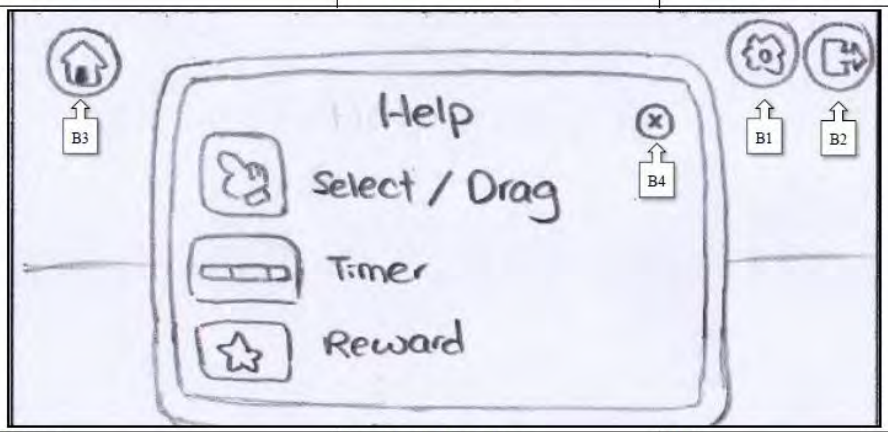
Screen Description:	**Functionality/Interactivity:**	**Audio:**
Main menu content three type of buttons which will link to another page.	B1: Link to setting screen B2: Link to exit screen B3: Will link to choosing level page B4: Link to credit page B5: Will link to help page	- Background music - Button clicking sound

Screen: Screen 4 (Credit)	**Links from screens:** Main Menu	**Links to screens:** Main Menu



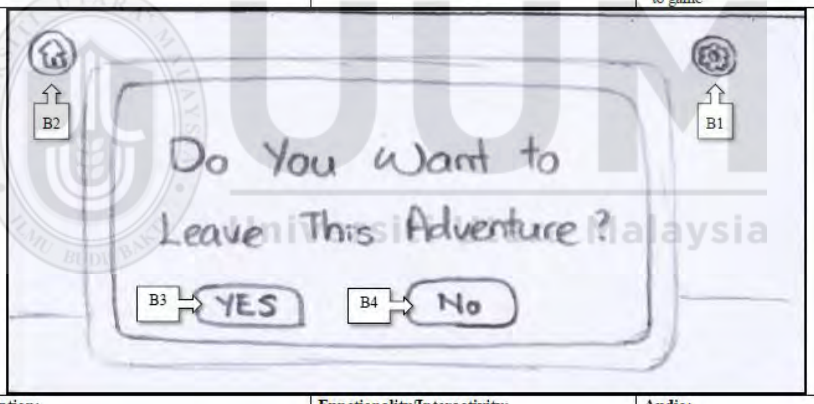
Screen Description:	**Functionality/Interactivity:**	**Audio:**
This page will display credits for the developers	B1: Link to setting screen B2: Link to exit screen B3: Link To main menu B4: To close the credit pop-up	- Background music - button clicking sound

Screen: Screen 5 (Help)	**Links from screens:** Main Menu	**Links to screens:** Main Menu

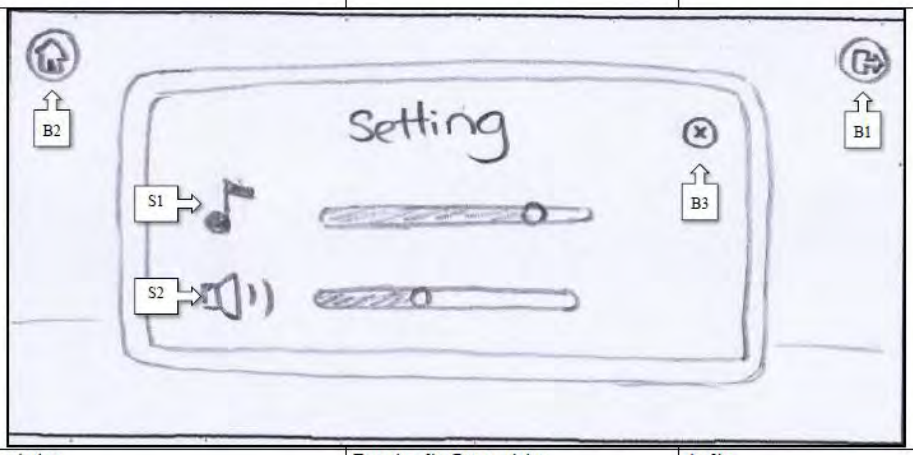


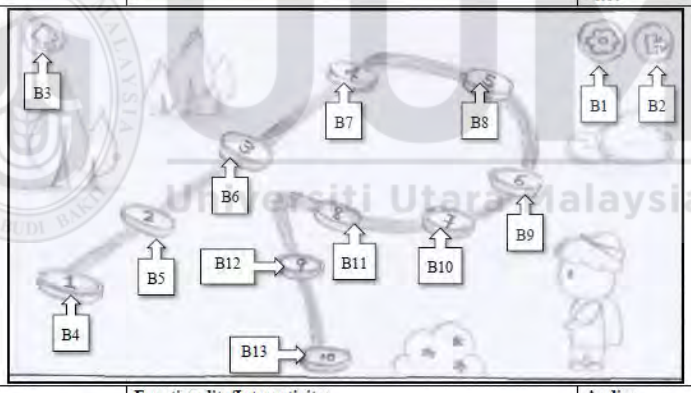
Screen Description:	**Functionality/Interactivity:**	**Audio:**
- Help page display when player click help button at main menu page. - Help page display instruction for the game flow of the game and also rules of the game that should be follow during game play. - It also consists with PREVIOUS and NEXT button	B1: Link to setting screen B2: Link to exit screen B3: Link To main menu B4: To close the help pop-up	- Music from the video tutorial

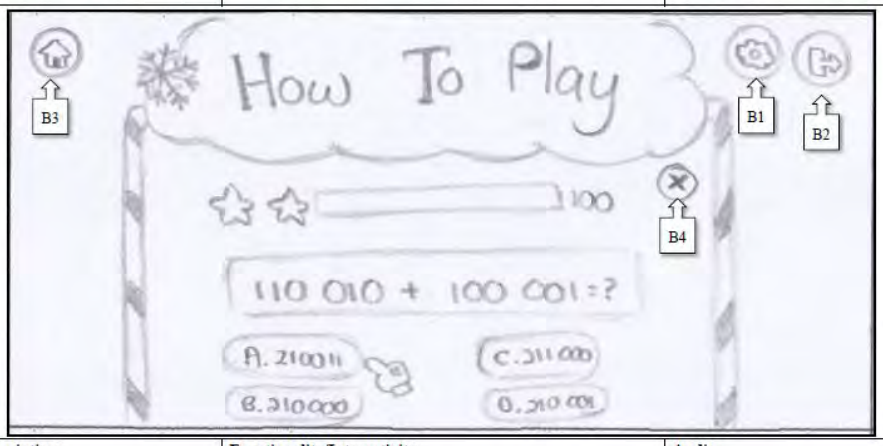
Screen: Screen 6 (Exit)	**Links from screens:** All the screen	**Links to screens:** Exit game and return to game

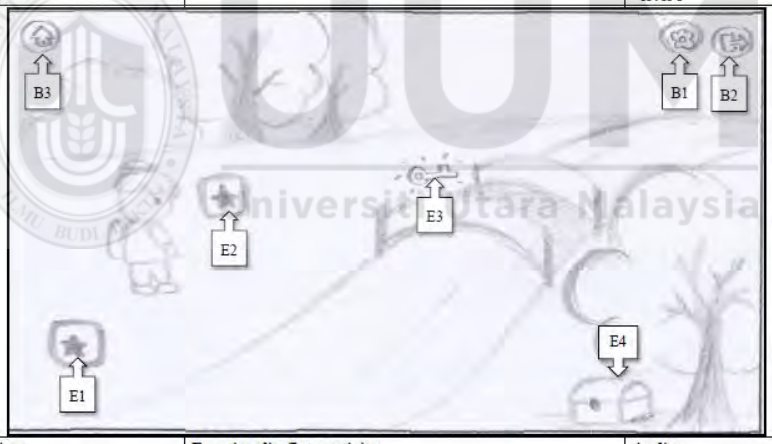


Screen Description:	**Functionality/Interactivity:**	**Audio:**
- Exit menu display when player decide to exit the game by click EXIT button at any screen or main menu. There will a short text will appear right after the player click EXIT button for receive confirmation either the player wanted to leave the game or continue back. - The player should click YES button if they really wanted to leave the game and NO button if they decide to continue back the game.	B1: Link to setting screen B2: Link To main menu B3: Exit the game B4: Return to game	- Background music - button clicking sound

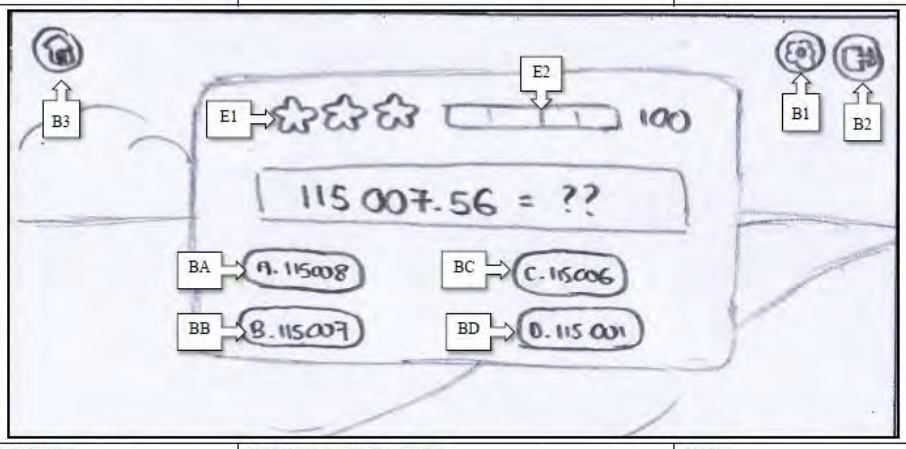
Screen: Screen 7 (Setting)	**Links from screens:** All the screen	**Links to screens:** All the screen
		
Screen Description:	**Functionality/Interactivity:**	**Audio:**
- This screen will display when player click setting button. In settings player can adjust volume of sound and background music by slide the slider.	B1: Link to exit screen B2: Link To main menu B3: To close the setting pop-up S1: Adjust background music S2: Control sound	- Background music - button clicking sound

Screen: Screen 8 (Select Level)	**Links from screens:** Main Menu	**Links to screens:** Level 1,2,3,4,5,6,7,8,9 &10
		
Screen Description:	**Functionality/Interactivity:**	**Audio:**
This Screen will display once the player click "Play" Button. This screen will show the map for selecting level where player can choose unlocked levels	B1: Link to setting screen B2: Link to exit screen B3: Link to main menu B4: Link to level 1 B5: Link to level 2 B6: Link to level 3 B7: Link to level 4 B8: Link to level 5 B9: Link to level 6 B10: Link to level 7 B11: Link to level 8 B12: Link to level 9 B13: Link to level 10	- Background music - Button clicking sound

Screen: Screen 9 (How to play for level 1 &2)	**Links from screens:** Select Level	**Links to screens:** Gameplay level 1 & 2
		
Screen Description:	**Functionality/Interactivity:**	**Audio:**
This screen will show instructions how to play level 1. This will be played as a video.	B1: Link to setting screen B2: Link to exit screen B3: Link to main menu B4: Skip to Game play	- Background music - button clicking sound - Sound from tutorial video

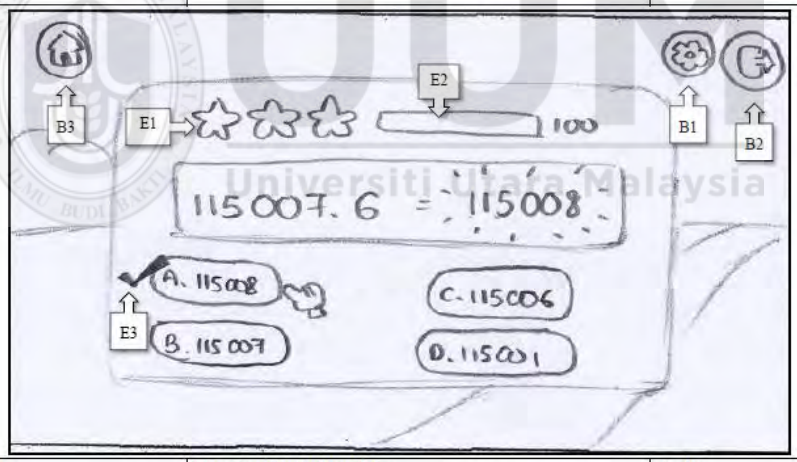
Screen: Screen 10 (Level 1 Gameplay)	**Links from screens:** Select Level	**Links to screens:** Question pop up for level 1
		
Screen Description:	**Functionality/Interactivity:**	**Audio:**
This is level 1 game play where it will be at jungle. The player must explore in the jungle and answer all the question provided to proceed to next level.	B1: Link to setting screen B2: Link to exit screen B3: Select Level E1: Link to pop-up question E2: Link to pop-up question E3: Key to unlock level E4: Unlock treasure box link to next level	- Background music - Button clicking sound - Object collecting sound

Screen: Screen 11 (Question pop up)	**Links from screens:** Level 1 gameplay	**Links to screens:** Answering question (Level 1)

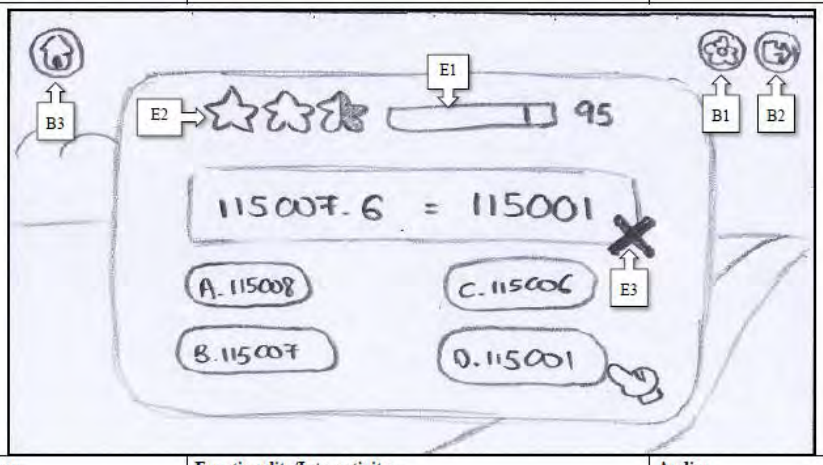


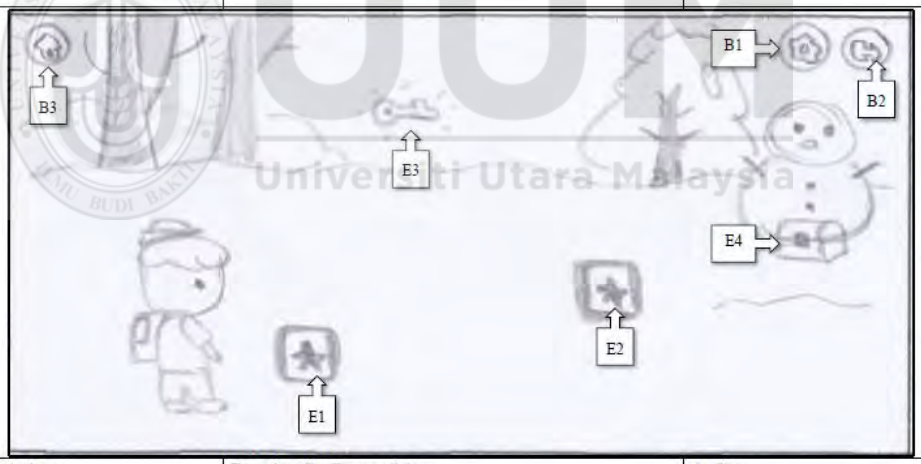
Screen Description:	**Functionality/Interactivity:**	**Audio:**
This screen will display the pop-up question that must be answered by the player. Player must choose one answer from the choices given as 'A','B', 'C', 'D'.	B1: Link to setting screen B2: Link to exit screen B3: Select Level BA: Link Right Answer & Wrong Answer BB: Link Right Answer & Wrong Answer BC: Link Right Answer & Wrong Answer BD: Link Right Answer & Wrong Answer E1: Collect award star E2: Time limit bar for each question	- Background music - Timer sound effect - Button clicking sound

Screen: Screen 12 (Right Answer)	**Links from** screens: Question pop-up	**Links to screens:** Question pop-up

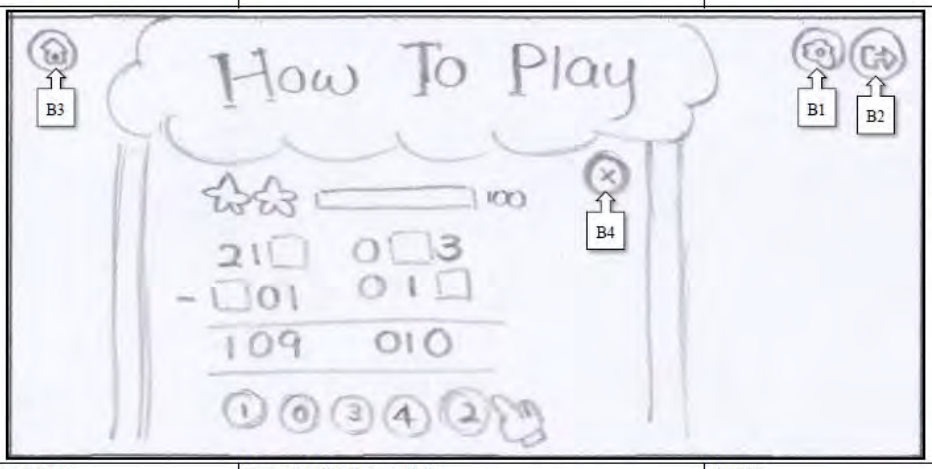


Screen Description:	**Functionality/Interactivity:**	**Audio:**
This screen will display If the answer choose by the player is Right.	B1: Link to setting screen B2: Link to exit screen B3: Select Level E1: Collect award star E2: Time limit bar for each question E3: Correct icon pop-up when choose the correct answer	- Background music - Correct answer sound effect

Screen: Screen 13 (Wrong Answer)	**Links from screens:** Question pop-up	**Links to screens:** Question pop-up
		
Screen Description:	**Functionality/Interactivity:**	**Audio:**
This screen will display If the answer choose by the player is Wrong	B1: Link to setting screen B2: Link to exit screen B3: Select Level E1: Collect award star E2: Time limit bar for each question E3: Wrong icon pop-up when choose the wrong answer	- Background music - Wrong answer sound effect

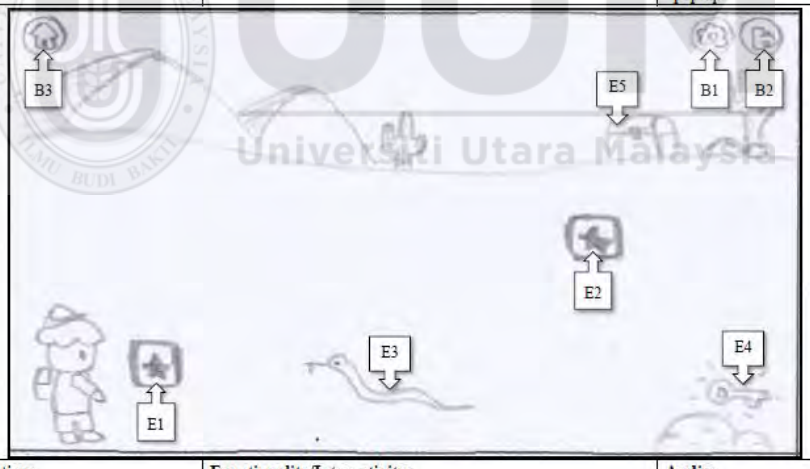
Screen: Screen 15 (Level 2 Gameplay)	**Links from screens:** Select Level	**Links to screens:** Question pop-up
		
Screen Description:	**Functionality/Interactivity:**	**Audio:**
This is level 2 game play where it will be at snow environment. The player must explore and answer all the question provided to proceed to next level.	B1: Link to setting screen B2: Link to exit screen B3: Select Level E1: Link to pop-up question E2: Link to pop-up question E3: Key to unlock level E4: Unlock treasure box and link to next level	- Background music - Button clicking sound - Object collecting sound effect

Screen: Screen 16 (How to play level 3)	Links from screens: Select level	Links to screens: Level 3 Gameplay

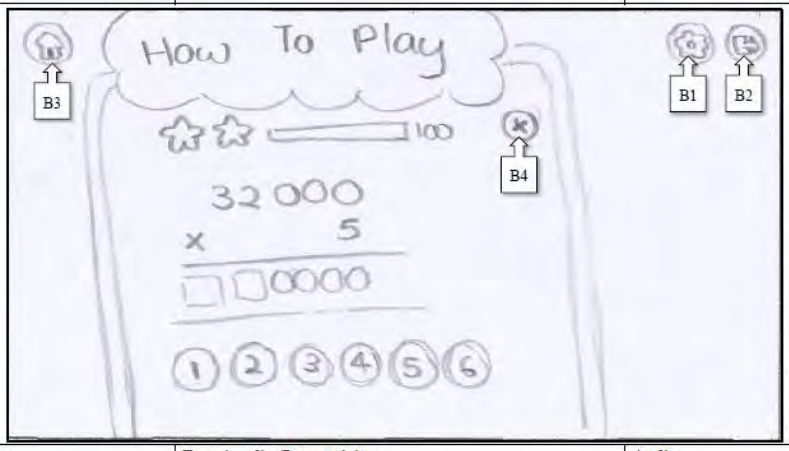


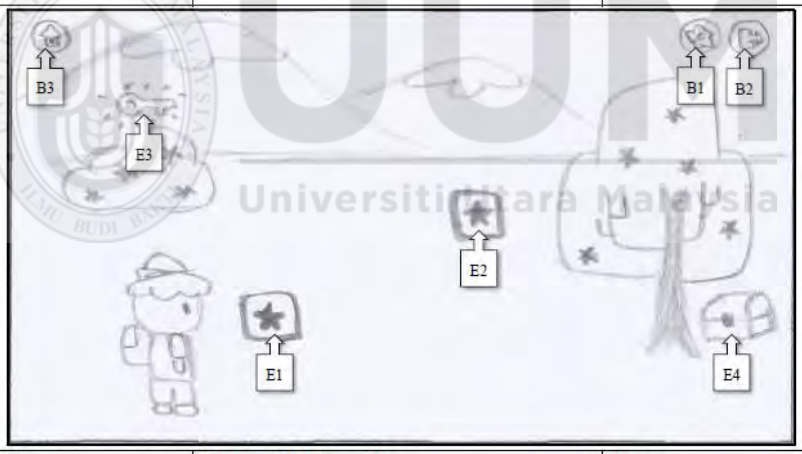
Screen Description:	Functionality/Interactivity:	Audio:
This screen will show instructions how to play level 3. This will be played as a video.	B1: Link to setting screen B2: Link to exit screen B3: Link to main menu B4: Skip to Game play	- Background music - Button clicking sound - Sound from tutorial video

Screen: Screen 17 (Level 3 Gameplay)	Links from screens: Main Menu	Links to screens: Select level & question pop-up



Screen Description:	Functionality/Interactivity:	Audio:
This is level 3 game play where it will be at summer environment. The player must explore the area and answer all the question provided to proceed to next level.	B1: Link to setting screen B2: Link to exit screen B3: Select Level E1: Link to pop-up question E2: Link to pop-up question E3: Obstacle come out to disturb player E4: Key to unlock level E5: Unlock treasure box and link to next level	- Background music - Button clicking sound - Object collecting sound effect - Walking sound effect

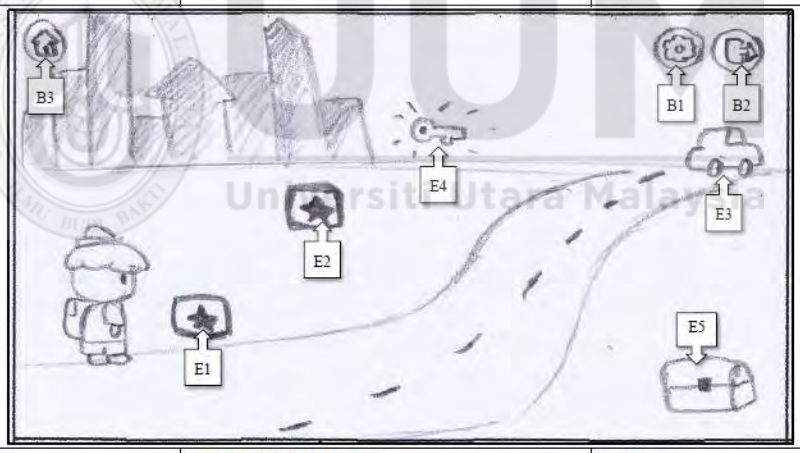
Screen: Screen 18 (How to play for level 4)	**Links from screens:** Select level	**Links to screens:** Level 4 Gameplay
		
Screen Description:	**Functionality/Interactivity:**	**Audio:**
This screen will show instructions how to play level 4. This tutorial will be in video form.	B1: Link to setting screen B2: Link to exit screen B3: Link to main menu B4: Skip to Game play	- Background music - Button clicking sound - Sound from tutorial video

Screen: Screen 19 (Level 4 Gameplay)	**Links from screens:** How to play level 4	**Links to screens:** Select level & Question pop-up
		
Screen Description:	**Functionality/Interactivity:**	**Audio:**
This screen will display level 4 game with spring season environment. The player must explore the area and answer all the question provided to proceed to next level.	B1: Link to setting screen B2: Link to exit screen B3: Select Level E1: Link to pop-up question E2: Link to pop-up question E3: Key to unlock level E4: Unlock treasure box and link to next level	- Background music - Button clicking sound - Object collecting sound effect - Walking sound effect

Screen: Screen 21 (Level 5 Gameplay)	**Links from screens:** How to play level 5	**Links to screens:** Select level & Question pop-up

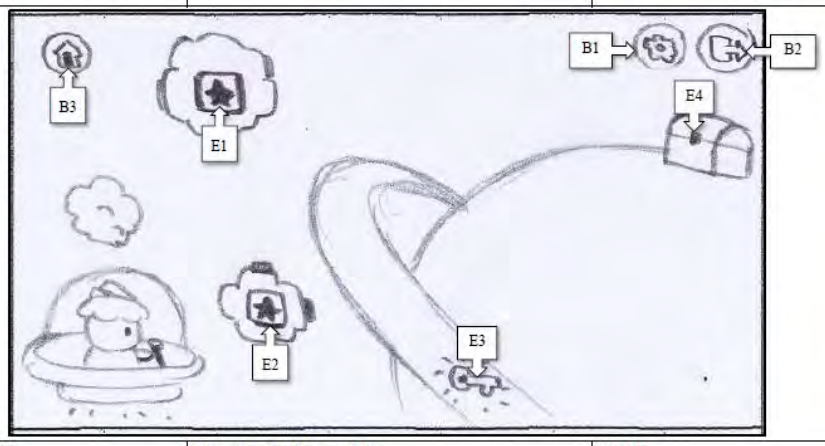
Screen Description:	**Functionality/Interactivity:**	**Audio:**
This screen will display level 5 gameplay at autumn season environment. The player must explore the area and answer all the question provided when the player collects an object to proceed to next level	B1: Link to setting screen B2: Link to exit screen B3: Select Level E1: Link to pop-up question E2: Link to pop-up question E3: Key to unlock level E4: Unlock treasure box and link to next level	- Background music - Button clicking sound - Object collecting sound effect - Walking sound effect

Screen: Screen 23 (Level 6 Gameplay)	**Links from screens:** How to play level 6	**Links to screens:** Select level & Question pop-up



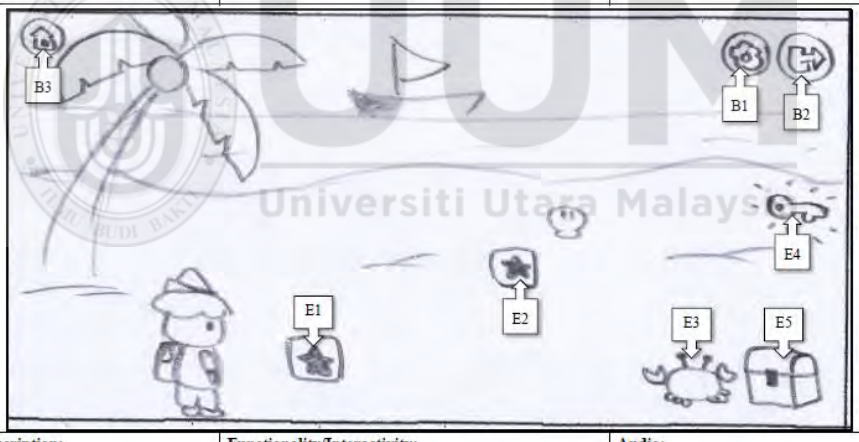
Screen Description:	**Functionality/Interactivity:**	**Audio:**
This screen will display level 6 gameplay at middle of the town area where the player must walk side way in that town collect an object to answer all the question provided to proceed to next level.	B1: Link to setting screen B2: Link to exit screen B3: Select Level E1: Link to pop-up question E2: Link to pop-up question E3: Obstacle come out to disturb player E4: Key to unlock level E5: Unlock treasure box and link to next level	- Background music - Button clicking sound - Object collecting sound effect - Walking sound effect

Screen: Screen 25 (Level 7 Gameplay)	**Links from screens:** How to play level 7	**Links to screens:** Select level & Question pop-up



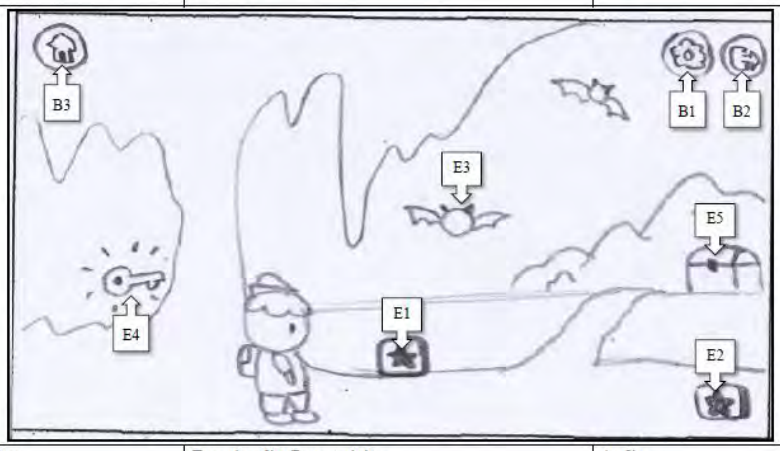
Screen Description:	**Functionality/Interactivity:**	**Audio:**
This screen will display level 7 gameplay in space where the player must collect all the object to answer the question and find key to open the treasure box and answer questions provided to proceed to next level	B1: Link to setting screen B2: Link to exit screen B3: Select Level E1: Link to pop-up question E2: Link to pop-up question E3: Key to unlock level E4: Unlock treasure box and link to next level	- Background music - Button clicking sound - Object collecting sound effect - Walking sound effect

Screen: Screen 27 (Level 8 Gameplay)	**Links from screens:** How to play level 8	**Links to screens:** Select level & Question pop-up



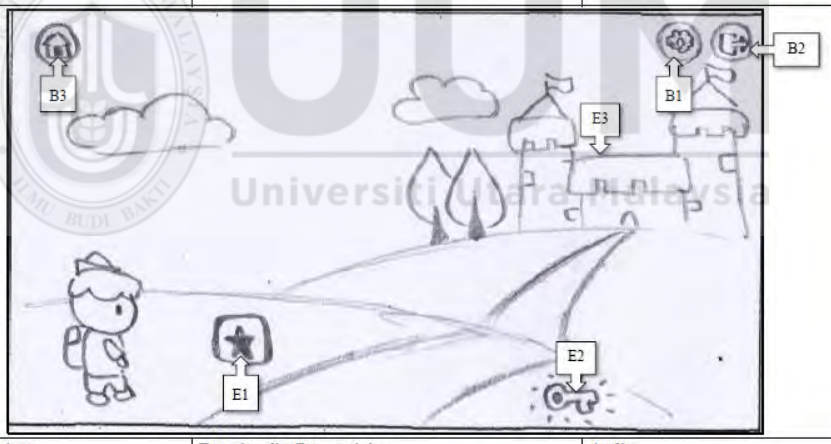
Screen Description:	**Functionality/Interactivity:**	**Audio:**
This screen will display level 8 gameplay at sea side where the player must collect all the object to answer the question and find key to open the treasure box and answer questions provided to proceed to next level.	B1: Link to setting screen B2: Link to exit screen B3: Select Level E1: Link to pop-up question E2: Link to pop-up question E3: Obstacle come out to disturb player E4: Key to unlock level E5: Unlock treasure box and link to next level	- Background music - Button clicking sound - Object collecting sound effect - Walking sound effect

Screen: Screen 29 (Level 9 Gameplay)	**Links from screens:** How to play level 9	**Links to screens:** Select level & Question pop-up

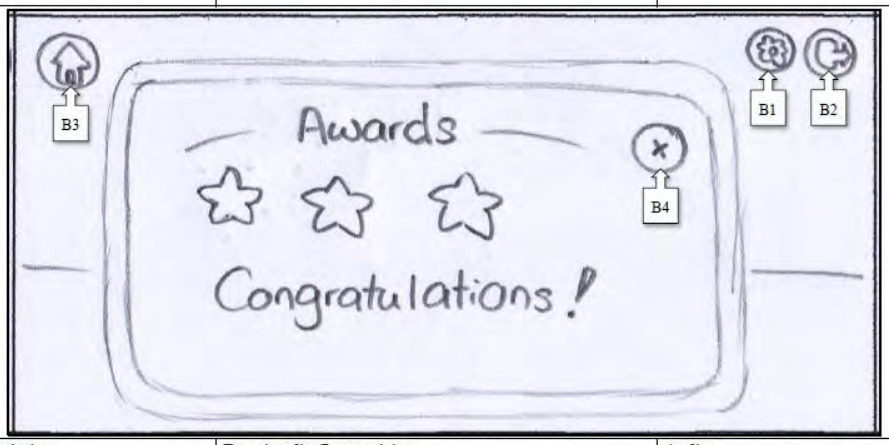


Screen Description:	**Functionality/Interactivity:**	**Audio:**
This screen will display level 9 gameplay that will inside a cave where the player must collect all the object appear to answer the question and find key to open the treasure box and answer questions provided to proceed to next level.	B1: Link to setting screen B2: Link to exit screen B3: Select Level E1: Link to pop-up question E2: Link to pop-up question E3: Obstacle come out to disturb player E4: Key to unlock level E5: Unlock treasure box and link to next level	- Background music - Button clicking sound - Object collecting sound effect - Walking sound effect

Screen: Screen 31 (Level 10 Gameplay)	**Links from screens:** How to play level 10	**Links to screens:** Select level & Question pop-up



Screen Description:	**Functionality/Interactivity:**	**Audio:**
This screen will display level 10 and also the final level in this level game that will inside a castle where the player must collect all the object appear to answer the question and find key to open the treasure box and answer questions provided to proceed to next level.	B1: Link to setting screen B2: Link to exit screen B3: Select Level E1: Link to pop-up question E2: Key to unlock level E3: Complete all levels	- Background music - Button clicking sound - Object collecting sound effect - Walking sound effect

Screen: Screen 32 (Awards screen)	**Links from screens:** Level 3, 6 & 10 gameplay	**Links to screens:** -
		
Screen Description:	**Functionality/Interactivity:**	**Audio:**
This screen will display the awards that collected by the players when the player complete level 3, 7 and 10 where the player will receive bronze, silver and gold.	B1: Link to setting screen B2: Link to exit screen B3: Select Level B4: Link to main menu	- Winning background music - Button clicking sound