EDUCATIONAL MOBILE GAME DESIGN FOR CHILDREN LEARNING MATHEMATICS

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Abstract

Children can learn while playing computer educational games. Therefore, it is important that educational games for children are well designed and usable. This study proposes an educational mobile game design for children to learn mathematics. Based on the design, a low fidelity and high fidelity prototypes called PreMath Operations were designed and developed. A usability evaluation was conducted on the prototypes by observing children playing with the games. The result of the evaluation suggested that PreMath Operations prototypes is usable and can help children to learn math while playing. This study provides a design strategy of mathematic educational game for children to learn in a fun and interesting.

Keywords: educational game design for children, edutainment app for mathematics, game design factors.

Abstrak

Kanak-kanak dapat belajar sambil bermain permainan komputer pendidikan. Oleh itu, adalah penting supaya permainan pendidikan untuk kanak-kanak direka dengan baik dan boleh digunakan. Kajian ini mencadangkan reka bentuk satu permainan pendidikan mudah alih untuk kanak-kanak belajar matematik. Berdasarkan reka bentuk yang dicadangkan prototaip fideliti rendah dan fodeliti tinggi yang dipanggil PreMath Operasi telah direka dan dibangunkan. Satu penilaian kebolehgunaan telah dijalankan ke atas prototaip dengan memerhatikan kanak-kanak bermain dengan permainan tersebut. Hasil penilaian mencadangkan bahawa prototaip Operasi PreMath boleh digunakan dan dapat membantu kanak-kanak belajar matematik. Kajian ini menyediakan strategi reka bentuk permainan pendidikan matematik kepada kanak-kanak untuk belajar dengan cara yang menarik dan menyeronokkan.

Kata kunci: reka bentuk permainan berasaskan pendidikan untuk kanak-kanak, aplikasi berasaskan hiburan untuk matematik, faktor reka bentuk permainan.

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CHAPTER ONE

INTRODUCTION

1.1 Overview

During the past years, there has been an increased in the use of digital technology and social networks. These technologies are also starting to play bigger parts in teaching students from pre-school to higher education (Garrison, 2011; Laurillard, 2005). Mobile communication devices are one of the most important and popular technologies among people nowadays. The functions of mobile communication devices have now gone beyond the traditional communication role which they used to play. It could now be used for teaching and learning as well (Mtega, Bernard, Msungu, & Sanare, 2012). These days, children use mobile phones mostly for entertainment purposes; many of them play games regularly. Given the importance that some of these games have in stimulating and promoting children's skills, the researchers are looking into the utilisation of such games in education and learning (Durkin, Boyle, Hunter, & Conti-Ramsden, 2015). Because of the mobile game industry continues to thrive and the increasing demands and growing markets have made it possible for mobile game developers to come up with numerous mobile games (Amory, & Seagram, 2003). Moreover, with the recent technological advances, digital games have become new tools for teaching as well (Frost, Wortham, & Reifel, 2008).

According to Van Eck (2006), learning through games is a method that has been in used in education for decades. Today's generation of students can access technological advancements like computers, mobile phones, digital music and video players, and video games among others. These gadgets can be used as tools for

learning. Mobile devices, computers, and the Internet have all led to the rapid growth of mobile learning and have brought about big changes to the concept of education (Lu, Ting, Little, & Murphy, 2013). According to Ahmed and Parsons (2013), the main objective of mobile learning is to raise the efficacy of teaching methods and strategies that utilise computer-based teaching materials instead of just transferring them into mobile devices. Through this, learners are expected to have a broader range of knowledge and increased productivity. Games serve as interactive tools that teach us about goals, adaptation, rules, problem solving, and interaction. All these concepts are often presented as part of a story. Fundamental learning are given to us by providing enjoyment, structure, passionate involvement, motivation, adrenaline stimulation, ego gratification, creativity, emotion, and social interaction. "Play has a deep biological, evolutionarily significant function, which has to do precisely with learning" (Prensky, 2001).

Game designers are able to create interesting games but do not know how to maintain the quality of teaching materials in a game, whereas educators focused on effective educational factors but do not know how to create interesting games (Squire, 2003). For that Giannakos (2013), studied the factors of educational game such as Enjoyment, Happiness, and Intention and use them as important attitudes in learning educational games to increase learning performance. Shi and Shih (2015), found an effective educational game factors that are discovered the main reasons why students enjoy this game in order to help the designer more focusing on designing game that provide the knowledge and the entertainment in same time.

Generally, games being used in education were developed to strengthen the gathering of factual information. Educational games may be most suited for pre-school children and computer-based education games are a combination of education, entertainment, and the imitation of real-life environments (Almomani, 2012). It is said that educational games "are games designed with precise curriculum objectives in mind" (Royle, 2008). An educational game can therefore be seen as a game designed to teach humans a skill or educate them on a specific subject. Parents, educators, and governments are starting to acknowledge the benefits that gaming has on learning and, as a result, this educational tool is starting to become mainstream (Prensky, 2001). Compared to games that are made solely for entertainment purposes, mobile game-based learning (mGBL) possesses value-added educational contents and specific learning goals. Moreover, mobile game players are always looking for mGBL that will motivate them to play and learn several educational skills such as alphabets and mathematics at the same time (Amory, & Seagram, 2003).

mGBL is a game that can be played on handheld devices like mobile phones. It is one of the most recent emerging research areas. Some of its main goals are to enhance learning motivation using game play, use the mobile environment to improve the efficacy of learning activities, and get involved in obtaining knowledge (Syamsul Bahrin, 2011). Some researchers found the decreasing interest of students in mathematics has been partially attributed to the methods used in teaching mathematics in schools (Rocard, 2007) and the way by which mathematics is taught in schools is one of the reasons for the declining interest in the subject. Some researchers found mathematics is more easily learned when students are given

opportunities to engage in discourse that encourages the generation, sharing, investigation, discussion, and validation of mathematical ideas as methods to nurture students' mathematical reasoning (Franke & Kazemi, 2001; Herbel-Eisenmann & Cirillo, 2009).

1.2 Problem Statement

A number of researchers have proposed various game design models and development methodologies. They are available in various game genres and they all have specific requirements (Kiili, 2005; Amory, & Seagram, 2003). For example, Ketamo (2002) developed an adaptive geometry game that observes a player's effectiveness in order to provide the player with appropriate problems. But he found the game provide particularly low level of geometry knowledge with good effectiveness. Barbosa, Pereira, Dias, and Silva (2014), found that children do not like educational games because it does not give the feeling of "playing", and that can be termed as dull and unexciting. According to Fengfeng (2014), design-based learning that can engage students, must make integration between the targeted content knowledge and the products designed.

Furthermore, on educational game design by Cagiltay et al. (2015), present the cause and effect relationship between factors such as competition, motivation, performance measures in game and learning outcomes. However, they suggested the need of additional elements (such as uncertainty, goals, challenge, learner control, cooperation, fantasy, interactivity and flexibility) to be used as a general model to any educational game.

Hamari, et al. (2016), investigated factors such as skill, challenge and engagement that increased challenge, skill, engagement, and immersion in a game or

gamified experience will have a beneficial effect on learning. They found that increased engagement in the game has a clear positive effect on learning and challenge will have positive effect via increased engagement. For immersion there is no significant effect in game and learning but skill did not affect learning directly by increasing engagement in the game. This model does not cover all effective factors that lead to design an educational game in fact it still need more factors in order to increase the immersions and other effect factors.

On the other hand, Shi and Shih (2015), found 11 crucial game-design factors that assist educational game designers in developing interesting games. The game factors will differ in designs and weights depending on the game goals and genre. Also it focuses on making educational game design more fun. So to design a useful mobile game-based learning the Shi and Shih factors are considered in this study because this model is a comprehensive model that provides this number of usable factors to design educational game for basic mathematical skills for children.

This study, will adopt the factors of Shi and Shih (2015) model that is made for game based learning in order to propose a mobile game design strategy that could potentially improve the design of edutainment game which addresses previous deficiencies (i.e. some absent factors in educational mobile games that make these games boring or not excitement). The main objective of mobile learning is to raise the efficacy of teaching methods and strategies that utilise computer-based teaching materials instead of just transferring them into mobile devices. So the propose of our mobile game design strategy considers:

a) The syllabus by ministry of education Malaysia for standards 1, 2 and 3 of primary school children.

b) Exciting mobile games did not developed based on any education game design model or framework.

1.3 Research Questions

1. What are the key factors that should be considered in designing educational games for mathematics targeting children between 7 to 9 years old?
2. How can the identified factors be incorporated into educational game for mathematics?
3. Is the proposed educational game design usable for children to learn mathematics?

1.4 Research Objectives

1. To identify various educational game factors for designing educational game for children.
2. To design a mathematical educational game based on the identified game factors.
3. To evaluate the usability of the proposed educational game design by measuring effectiveness, efficiency and satisfaction.

1.5 Scope

This study explicitly aims to cooperate 11 factors (game goals, game mechanism, game fantasy, game value, interaction, freedom, narrative, sensation, challenges, sociality, and mystery) that designed by Shi and Shih (2015) to develop a mobile educational game application for primary school children to help them learn

mathematics by mobile devices (like smartphone, tablet, etc) because of the ease of use and children fondness on these devices. The educational mathematics game is designed for primary school children aged seven to nine years old (Dunning, Holmes, & Gathercole, 2013) and its content covers the mathematical operations presented on the Kurikulum Standard Sekolah Rendah (KSSR) syllabus for primary school. The game provides multi algebra skills for calculation like addition, subtraction, multiplication, and division. Moreover provides problem solving that will provide engagement and entertainment. So from that were hoping to breach the gap between educational and entertainment games.

1.6 Significance of Research

This study will give more options and alternative methods of learning for primary school children, particularly in the field of mathematics the factors that identified will contribute to a more effective educational game design. It can also help determine the urgency of the need to develop an educational mathematics game for them. Furthermore, this application can be used as a new learning method and tool for children in primary school.

1.7 Summary

This chapter elaborates on the overview of the research conducted to propose a specific design of mathematical educational game for children following the KSSR syllabus. It also looks at the feasibility of using mobile contents as learning tools. It takes a look at the numerous advantages of utilising games in the learning process. The objectives and importance of this study is also described here. This aspect is considered as the key part of the implementation of this application. The literature review on related study is presented in the following chapter.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The literature pertaining to this study, like game-based learning, instructional design model, and learning approaches are described in this chapter. This chapter focuses mainly on reviewing the existing literature about methodologies for developing mobile games, instructional design models, and game-based learning models. The review will reveal the need for a more comprehensive design for developing mGBL.

2.2 Game Definition

A game is commonly defined as an activity which is undertaken for enjoyment. Several researchers have defined game in different ways based on their own preferences. In this study, the term 'game' will refer to any digital game. Prensky (2001) has defined game as an organised play that gives players pleasure and enjoyment. On the other hand, Dempsey (1996) defines a game as a group of activities that involves players (one or more) and has goals, payoffs, constraints, consequences, rules, and competition. A game immerses its players in its imaginary world (Fabricatore, 2000), and engages them in an artificial conflict that has rules and a quantifiable result (Salen & Zimmerman, 2003). Moreover, games provide players with motivation through fantasy, challenge, and curiosity (Randel, Morris, Wetzel, & Whitehill, 1992).

To reach the game's goals, players have to make decisions that will help them manage the resources of the game (Costikyan, 1994). There are numerous game definitions but (Juul, 2003) was able to come up with a selection of important game

definitions with six points. A game is said to have i) rules, and ii) results, iii) each outcome has different values which motivate, iv) players to reach these outcomes, v) get themselves attached to the outcomes, vi) and the consequences of the activity will always be negotiable and optional. For decades, games and game-based learning have been parts of education. Given the new technological advances nowadays, digital games have become new teaching tools. It has been proven by neuroscience that "Games are tailor-made to fit the very different tasks humans will encounter" (Frost, Wortham, & Reifel, 2008).

Rieber (1996) concludes that games represent instructional artefacts that most closely resemble the characteristics of learning environments that are intrinsically motivating: curiosity, fantasy, challenge, and control. Summarising all these definitions, it can be said that a game is played for enjoyment and that it has rules, a game world, goals, and interaction. A player makes decision based on the game's rules and achieves the game's goals by interacting with the game world. These characteristics will be used throughout this study to represent the kind of game being studied.

2.3 Mobile Learning

Mobile learning is defined as the intersection of mobile computing (the utilisation of portable and wireless computing and communication devices) and e-learning (learning that is facilitated and supported by using information and communication technology) (Clark, 1994). According to another researcher, mobile learning is a unique process that gives students the chance to personalise their learning wherever and whenever (Attewell, 2005). Lepper and Malone (1987) as cited in Schwabe and

Göth (2005) came up with a connection between learning and intrinsic motivation. They were able to determine seven main factors needed to create an intrinsically motivating instructional environment: challenge, control, curiosity, fantasy, competition, competition, and recognition.

2.4 Game-Based Learning (GBL)

GBL can be defined as a combination of computer games and educational content (Prensky, 2001). The educational content is made more interesting to the players by the hybrid incorporation between education and game entertainment (Aslan & Balci, 2015). As a process, GBL refers to the method in which students use the complete game software application in learning a subject. Comparing game with GBL, Pohl, Rester, Judmaier, and Leopold (2008) state that a game does not have an external goal and is only played for fun. GBL, on the other hand, always has an external goal, and that is to learn something. Additionally, Dondlinger (2007) describes GBL as something that has learning content as an additional characteristic. It can then therefore be said that a GBL allows a player to learn by utilising the game's characteristics. Overall, GBL's characteristics will give players engagement, motivation, learning environment, and feedback.

2.4.1 Categories of GBL

In categorising GBL according to their differences, one can use several approaches. These differences include variations in game format, devices, platform, content, and learning goals. Categorising GBL by genre is the most common method (Syamsul Bahrin, 2011). According to (O'Malley, et al., 2003), mobile learning is "any kind of learning which takes place when the learner is not on a fixed, predetermined location,

or learning which takes place when the learner takes advantage of the learning opportunities provided by mobile technologies".

According to Quinn (2005) most of the discussions about the categories of GBL are focused on game genres. He states that genres can be useful in gaining more understanding about the differences in games, their types of engagement, and giving templates for game development and design. Dempsey (1996) organised the GBL by the following genre: simulation, adventure, puzzle, experimental, modelling, motivational, and others. On the other hand, Griffiths (1996, 1999) broke GBL down into nine categories: sports (e.g. football), adventures (fantasy games), racers (e.g. car racing), plat formers (e.g. Mario Brothers), puzzlers (e.g. jigsaw puzzle), platform blasters (similar to plat formers but gives more focus on action and shooting), shoot 'em ups (e.g. shooting games), beat 'em ups (e.g. Street Fighters), and weird games (types which do not fit into the previous categories).

Not long after, Prensky (2001) identified similar game genres, which are capable of overlapping: puzzle, action simulation, adventure, strategy, role-playing, fighting, and sports. Later, Quinn (2005) came up with the following game genres: action, driving or flying, fighting, sports, card or board, 3D shooter, fantasy role playing, strategy, multiplayer, adventure, massively multiplayer online role-playing game (MMORPG), and combinations of genres. Bergeron (2006) also further expanded the standard GBL genre: action, arcade (retro), adventure, combat (fighting), first-person shooter, driving, military shooter, puzzle, multiplayer, real-time simulation, role playing game, shooter, sneaker, simulation, sports, third-person shooter, trivia, strategy, and turn-based. However, Kirriemuir and McFarlane (2004)

has stated that every year, there are games that are released that do not seem to belong into these genres. Apperley (2006) argues against these genres that are currently used to classify games. He instead pushes for the categorising of these games based on the type of interaction that they provide.

2.4.2 Mobile Game-Based learning (mGBL)

Soykan and Uzunboylu (2015) discovered that there are many studies done on mobile education. These studies reveal that mobile technology has been used effectively and have therefore given rise to numerous new research as well. The term mGBL pertains to GBL which uses mobile technologies like Personal Digital Assistant (PDAs), mobile phones, and other handheld devices as playing platforms. Mohamudally (2006) describes the concerning issues of mGBL as mobility and the restrictions that mobile technologies have. Furthermore, he claims that the concepts of mGBL are based in the pedagogical theory and are adjusted to the technical capabilities and the standards of mobile phones that we have now. mGBL applications are developed for a wide variety of learning methods like multiplayer games and role play (Sanneblad & Holmquist, 2003; Lonsdale, Baber, & Sharples, 2004; McAlister & Xie, 2005; Mohamudally, 2006). While some mGBL applications focus on collaboration (Sánchez, Salinas, & Sáenz, 2006), others can also be played individually (Krenn, Böhme, & Mitchell, 2008). Mitchell, et al. (2006), for example, came up with the three-year pan-European funded project. This project has mGBL prototypes in three sectors: i) e-commerce, ii) e-health, and iii) career guidance. The project's basis was the research findings by (Mitchell, 2003) and (Mitchel & Savill-Smith, 2004).

2.5 Edutainment concept and children learning

Entertainment is one of those issues which are presently becoming popular in certain aspects. Entertaining these days is not only focused on the traditional scope of entertainment but also in providing better products and experiences (Wolf, 2000). Edutainment is a concept that combines education and entertainment. This definition divides edutainment into two major scopes: pedagogy of education and entertaining experiences. Thus, an edutainment design concept should have entertainment and educational aspects. This term can also be defined as a medium for teaching and learning using entertainment and education at the same time (Wan, 2010). The key objective of this is educating and teaching people by using entertainment. Thus, one can make children more interested in learning by utilising these interactive and interesting applications. The next section will describe the educational game that will be the main focus of this study.

2.6 Educational Games

An educational game is defined as a game that is made mainly to teach a specific subject or skill to humans. Because educators, parents, and governments are starting to see the psychological benefits that gaming has on learning, this educational tool has become mainstream (Prensky, 2001). The educational context becomes more interesting for players because of the hybrid combination of education and game entertainment. Unlike a regular game where there is no peripheral objective and which is enjoyed for fun, Lew (2013) maintains that game-based learning is distinguished by the normal inclusion of some external objective such as studying new things.

Instead of moving to purely mobile applications of the methodology, the use of educational techniques and resources derived from computer-based approaches needs to be strengthened by pursuing effective mobile learning paradigms. Swift developments in mobile-based education due to internet, computer, and mobile advances have led to huge shifts in learning theories. As a result, it is anticipated that newer students will be more productive and acquire wider outlooks (Lu, Ting, Little, & Murphy, 2013; Ahmed & Parsons, 2013). Learning games are diversions conceived according to particular curriculum objectives (Royle, 2008), and games have frequently been created with educational applications in mind, which encourage the practical dissemination of accurate information. Children and their games are a constant, and lessons formatted as fun educational experiences might be most effective in imparting information to preschool children (Su & Cheng, 2013). Educational games centred on computer-based instruction are a blending of learning and recreation which approximates actual settings. The latest educational approaches have been increasingly successful due to the fortunate evolution of study methods centred on mobile devices, which offer mobile-aided as well as group study and game-based learning (Kim, et al., 2012; Su & Cheng, 2013). Padilla-Zea et al. (2013) present the process followed to incorporate mobile storytelling in the educational videogame target applying on children aged from 3 to 7 years old. Maertens, Vandewaetere, Cornillie, and Desmet (2014), study the use of adaptive item sequencing in an educational math game (Monkey Tales) as a way to provide learning content that is adapted to the knowledge level of the children or player.

Aleven, Myers, Easterday, and Ogan, (2010), designed an educational game called Zombie Division to help children 7-8 year old to develop both a conceptual understanding of division as the inverse of multiplication and skill and fluency in

making divisibility judgments with whole numbers. From above we could find the educational mobile game manage to help the teachers to teach the children by exploiting technology and the children were very interested in using it.

2.7 Effective methods in game-based education

The usage of mobile technology in the special education field has started and is growing due to their advanced implementations of visual features. The technology's interactive capabilities are among its most significant benefits for this targeted audience (Fernández-López, Rodríguez-Fórtiz, Rodríguez-Almendros, & Martínez-Segura, 2013). It was averred that children are making use of these devices as their sizes enable more interactive and thus successful learning (Venkatesh, Greenhill, Phung, Adams, & Duong, 2012; Yee, 2012). E-learning and mobile-based settings can be further translated into cloud-based paradigms. In this field, cloud-based systems work to effectively ease the sharing of information, and are deployed to support many of the mobile technologies utilised in distributing information. With cloud-based computing deployments, permanently storing information while securing and sharing the resources more effectively is achievable (Banica, Stefan, & Rosca, 2013). The findings of some researches support arguments that cloud-based technology will persistently evolve in the next few years, and that the current developments will enable future research to arise (Dinh, Lee, Niyato, & Wang, 2013).

It was proposed that as a method of enhancing pupils' orientation regarding mathematical principles, a learning game can be useful (Meletiou-Mavrotheris & Mavrotheris, 2012). Education games have been demonstrated to appeal to pupils and to capture their interest, encouraging greater enthusiasm and connection in their

math subjects (Sqire, 2005; Young-Loveridge, 2004; Ke, 2008). Highly accomplished pupils exhibit greater amounts of emotional and interactive connection; it was likewise shown that math accomplishments and attitudes are significantly associated. Even though the success of education games in teaching cannot be concluded for now in most studies (Fletcher, & Tobias, 2006), the suggestion that suitably devised learning games can potentially improve math education among children has much evidence in its favour (Klawe, 1998; McGivern, et al., 2007; Simpson, Hoyles, & Noss, 2006). Learning games can help young students to concentrate on understanding mathematical concepts and solving problems, relegating cookbook instructions and derived forms as secondary concerns (Pratt, Winters, Cerulli, & Leemkuil, 2009). This is best done by presenting challenges which spark interest in children through a process of meaningful discovery. Young pupils acquire useful talents in learning games, like deliberate judgement, organisation, communications, functional numeracy, negotiation ability, collaborative decisions, and data handling (Kirriemuir & McFarlane, 2004; Pratt, Winters, Cerulli, & Leemkuil, 2009).

New learning games are becoming popular in diverse subjects and are especially widely used in commercially-available children's math education software. The position on motivating children via technologies which can entertain as much as educate has been particularly covered by studies (Hourcade, 2015). A guide to the foundational principles in designing a learning game is offered in (Fisch, 2005). Telling stories can make studying a more rewarding experience for young students, and is a strategy which many learning games share, although it is also

useful outside of game settings (Cassell, 2004; Hourcade, Bederson, & Druin, 2003; Hourcade, Bullock-Rest, & Hansen, 2012).

It was recommended by Sharples, Arnedillo, Milrad, and Vavoula (2008) that specific teaching goals should guide the activity schemes of mobile learning methods. These should be further employed to emotionally connect children to promoted activities, in ways which are only now realisable via the available of new mobile technologies. Given the significance of some games in promoting skills and in motivating youth to acquire them, researchers operate on the assumption that many can be exploited for educational purposes. This must be balanced against the fact that some games impart only single estimation processes while neglecting related operations (Durkin, Boyle, Hunter, & Conti-Ramsden, 2015). One researcher conceived of an edutainment game which only taught fractional and partial operations to children while foregoing the remainder (Deater-Deckard, El Mallah, & Chang, 2014). The interactive aspects of interfaces should also be addressed in the product design of games for youthful users. As reported in (Wan, 2010), Moore (2001) averred that icon animations can better impress on children that the multimedia learning applications they are using exemplify games.

Including digital storytelling in education video games (EVGs) is an important element in maintaining the motivation associated with the game and learning process. Padilla-Zea, Gutiérrez, López-Arcos, Abad-Arranz, and Paderewski (2014), presented an extension of design process in a model as a set of Scenes and the process followed to incorporate mobile storytelling in the educational videogame. Morford, Witts, Killingsworth, and Alavosius (2014), suggested specific elements of

games should be investigated regarding their effects on behaviour—specifically the degree to which individuals prefer programs with various components and how well those elements maintain responding. Game elements here refer to design components of games (e.g., challenges, storytelling, character levels, etc.) rather than characteristics of game-playing.

It was reported by Inkpen (2001) that pre-schoolers performed more cleverly using interactive point-and-click interfaces, as they find these more easy to use than pens or papers. To be sure, it is the content of lessons and how they are conveyed which establishes what pupils can learn from them, and teachers direct and plan these lessons according to what they know and are able to deliver. So-called Exergames are demonstrably adaptable to specific requirements such as for visual deficiencies as per (Best, 2013), and apparently result in increased involvement and exercise satisfaction (Morelli, Folmer, Foley, & Lieberman, 2011; Boffoli, Foley, Gasperetti, Yang, & Lieberman, 2011). Transformation in teaching methods is among the most significant issues in educational progress, for improvements in student math education outcomes are directly associated with improvements in learning methods and teacher quality. This is the shared discussion which is arising in educational research (Hiebert & Stigler, 1999). So all of the methods pointed to the important of mixing between the entainment games and education game (edutainment) in order to enhance the education for student and to give the new tool for teacher that help them in teaching.

2.8 Effective factors of educational game

According to Aleven, Myers, Easterday, and Ogan (2010), an educational game should be effectual in terms of being an educational tool and as a pleasurable game.

Games involve interactive plays through which they can educate individuals with target attainment, acclimatisation, problem solving, rules, and interaction by exhibiting these concepts in the form of a story. Games provide the basic essentials of learning by rendering amusement, avid involvement, structure, drive, ego satisfaction, adrenaline, ingenuity, emotion, and social interface. Play has a profound biological, evolutionarily significant function which is associated specifically with learning (Prensky, 2001).

So what is it that makes video games effective? The most notable attributes of video games are as follows: (i) video games set a clear target – the majority of the video games are target-oriented; in other words, they boast of a plain, particular objective which the user should endeavour to achieve (for example, reaching a specific destination or seizing the princess); (ii) acceptable difficulty level which is neither very high nor very low – well-made games are extremely thought-provoking and cannot be entirely mastered most of the times; (iii) high speed – the majority of video games are quite faster compared to the conventional mechanical games; (iv) Integrated instructions – the majority of video games are designed in such a way that the user understands the instructions when he/she is playing the game and does not need to read them separately; (v) no binding of physical laws – Video games typically defy the physical laws of the universe, i.e. objects can glide, whirl, alter colour, and change shape at will; and (vi) engaging – video games engage players even as they construct a micro world with their own rules and directives (Provenzo, 2013). Furthermore, increased attention, enthusiasm, and focus are associated with the viewpoint that kids are drawn cognitively and visually towards an activity; in other words, it is fun for them. As per Hubbard (1991), the norms of attractiveness

should reign when conceiving educational software. Learning is something that is secondary for players.

According to Cagiltay, et al., (2015), they studied the cause and effect relationship model between competition, motivation, performance measures in the game and learning outcomes in order to guide the serious game designers for improving the potential benefits of serious games. Their study showed that when a competition environment is created in a serious game, motivation and post-test scores of learners improve significantly. But they found motivation was not associated with response-time and accuracy. So the model that they created need adding more elements (such as uncertainty, goals, challenge, learner control, cooperation, fantasy, interactivity and flexibility) to use it as a general model to any education game because it is focuses on just the competition element. Figure 2.1 shows the model design.

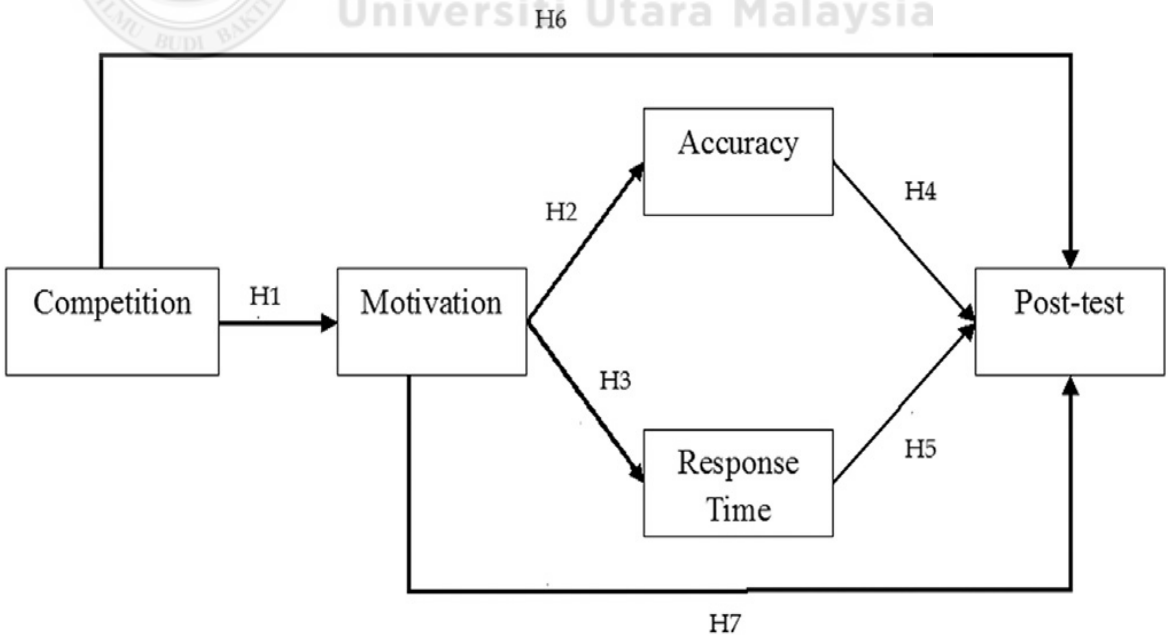


Figure 2.1: The model of Cagiltay, et al., (2015)

Hamari, Juho, et al. (2016), they designed model that investigated the increased challenge, skill, engagement, and immersion in a game or gamified experience will have a beneficial effect on learning. But they found the increasing of engagement in the game has a clear positive effect on learning and the challenge will have positive effect via increased the engagement. For the immersion there is no significant effect in game and learning but skill did not affect learning directly by increasing engagement in the game. So this model needs more improvement and more factors in order to enhance student skills. Figure 2.2 will show the relation between these elements.

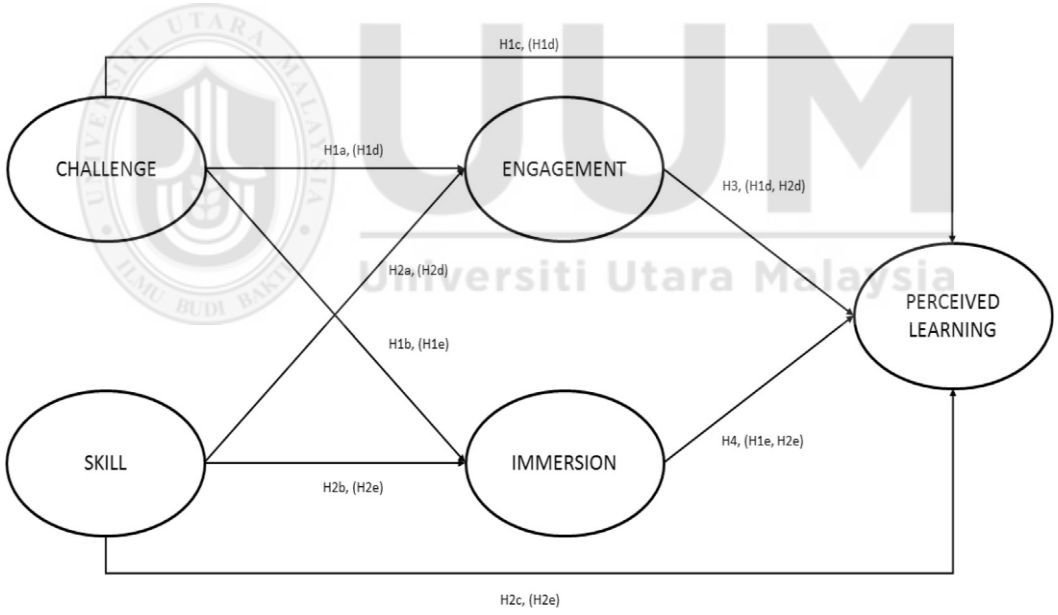


Figure 2.2: Model for Hamari, Juho, et al. (2016)

Shi and Shih (2015), is a model that covers most recent factors that study the effectiveness and the fun in designing an educational games. The following factors make gaming more amusing and entertaining: game targets, game structure and process, fantasy, interface, liberty, sensation, narrative, game value, sociability, challenges, and mystery. Each component in a game can be checked based on these

factors. For instance, the purpose of a learning math might be providing a method for players to solve equations and recycling game currency. This model can reduce the design negligence and clarify the causality of each factor. Furthermore it is a suitable and more related for our work because the boring of math games and low interesting in math material led us to search on such general model that provides the two points education and entertaining and this model mixed these two points. So this model will provide to our study pedagogy with pleasure and it is effective for children. Figure 2.3 illustrates the general model for Shi and Shih.

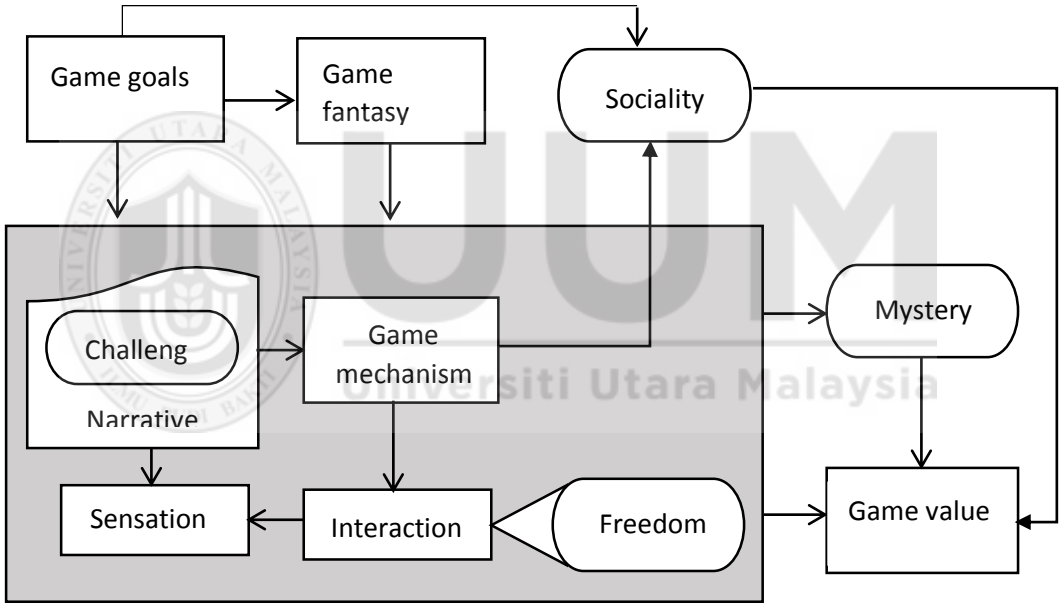


Figure 2.3: The general model for Shi and Shih (2015).

As you seen in Figure 3, the model starts with the game goals, and it includes teaching objectives and the experience they want to provide for players. The user experience is closely related to the game fantasy factor because it defines the virtual world imagery and gives players a dream when they are gaming. Game fantasy must be selected in the subsequent step. The teaching materials should be integrated into the game design rather than simply joining them. Therefore, the materials are

abstracted into the game and blended with game fantasy to form the game learning content. All implementations of the factors are based on game goals, and all elements must fit game fantasy.

The challenge factor must be considered first, because it usually associates with the teaching objectives (J. P.Gee, 2003). Certain game challenges are generated from teaching objectives and learning content, and they test the player's knowledge and skill. For narrative factor is often used to encapsulate teaching content and challenge, and it would make them less strange in the game. It is suitable for transmitting knowledge, which can be combined with the storyline to facilitate player absorption.

Sensation is built based on narrative of course, and it provides visual displays, such as images and 3Dgraphics, to show the virtual world. The game mechanism determines the interactions between the player and the computer, and the interactive interface influences game sensation. The learning feedback in educational games is a type of interaction, which is crucial in guiding students to learn. Freedom extends answer choices to increase the degree of learning difficulty and challenge, and it provides a game abundance. Sociality is a unique factor, and its implementation is determined by game goals. It can involve a simple interface for communication or for players to battle with others, and its design is based on the game mechanism. Mystery can be implemented in any aspect of the game. It inspires players to want to know more about the game, such as what will happen next in the story and whether there is more beautiful scenery in unexplored areas and more challenge and variety in later levels (Garris & Ahlers, 2001). All factors could assist

players to generate their own game values, and if an educational game could provide attracting game values, people will enjoy playing and learning simultaneously.

For Cagiltay, et al., (2015), they designed a model that studies one factor (competition factor) and the effective of this factor on student learning. For that, their study showed when a competition environment is created in serious games, motivation and learning outcomes through the game improved significantly. Hamari, Juho, et al. (2016) designed model that focus only on four factors and their effective on perceived learning for example challenge has a direct and a mediated effect (through engagement) on perceived learning, whereas skill only has a mediated effect, and the immersion did not have significant relationship with perceived learning. The lack of association between immersion and perceived learning may be caused by several factors. So the two models above were designed to implement on one or two games and the one of the models studied only one factor and another model studied four factors and both of designers recommended for developing their models need to add more factors.

In Shi and Shih (2015), the model that they designed was an interesting model as it focuses on 11 crucial factors that are designed to assist educational game designers in understanding how to use the factors and making their game more interesting. Furthermore this model helps to make educational game design more fun. Xiong, et al. (2016), study the effectiveness of their proposed method which enables to numerically identify the components that need to be enhanced to improve the mobile game and help creators design a more attractive game by the paradigmatic rules. In this study, the Shi and Shih (2015) model is used for giving the educational game

designers ways to design an edutainment mobile game by classifying the fantasy factor into three types: (1) Japanese-style, such as series of Final Fantasy (2) Chinese-style, such as series of The Legend of Sword and Fairy (3) Western-style, such as series of Diablo and series of The Elder Scrolls. The result of their study is the game designers could refer to the game refinement values to ensure the level of excitement remains high towards the end of the game and improve the quality of the game. In another work by Xu (2016) a review of literature was conducted that includes empirical studies and theoretical articles from 2007 to present. Moreover Xu showed meaningful learning experience designs for mobile game-based learning and the important role playing by integrating mobile game design with instructional design principles. The result of their study the important for the researchers to think about whether designing the 3D learning environment is worth putting in effort as compared to the 2D learning environment and the game designer must focus on the game material and trying to match with curriculum of the schools (Xu, 2016). In this study, the Shi and Shih (2015) model is used for designing mobile game based learning and study what role of playing in teaching. Tubush (2016), explores the effect of mobile game design on foreign language acquisition through a French language game design project by studying the factors of Shi and Shih model (Tybush, 2016). From above and as conclusion the researcher use the Shi and Shi model to design an effective education game in order to fill the gap between the educational games and traditional games.

2.9 Math games review

In this section will explain briefly some education games ways to educate children and the missing factors of this games depend on some high reviews and some articles

that refer to it with mention what is factors that absent when we apply it on Shi and Shih general model:

Math Mage Flashcard Numbers: it is an educational game that teaches the children Addition, Subtraction, Multiplication and Division as you answer flashcard questions correctly, you progress through the levels and multiply your character's experience.

Oh no fractions: It teaches the children how to implement some operations on two fractions like: Compare, Add, Subtract, Multiply, Divide.

Candy Factory: it is an educational game that teaches the concept of fractions to middle school students based on splitting operations with partitioning and iterating.

Monkey Tales: Monkey Tales Games is a series of engrossing video games with a robust learning component tailored to every child. Monkey Tales Games' aim is not to instruct, but to help children rehearse and improve existing math and logic skills.

PlayKids preschool cartoon: it is an educational games and puzzles deigned to help children develop motor coordination, memory and prekindergarten skills.

ABC Mouse early learning: it provides accelerate learning, children literacy and math skills.

Math your teacher.com: it has more than 50 courses for elementary, middle, and high school math and each course has over 100 lessons and each course offers an entire year's worth of math tutoring and practice.

iTooch middle school: it provides more than 10000 exercises. It is a new and fun way of practicing and learning Mathematics and language arts.

Desmos graphing calculator: is an educational game that teaches the student how to draw their function or math equations.

Bedtime math: is game that give the children bed time math rather than bed time story with fun part of kids' everyday lives, as beloved as the bedtime story.

You can see Table 2.1 showed the educational games and its description and the missing education factors that have been created for children.

Table 2.1: Types of game for children

No	Game Icons	Title of educational game	Description	Missing effective factors of educational games
1		Math mage	Learn addition, subtraction, multiplication and division.	Too violent and no sociality factor
2		Oh no fractions	Learn addition, subtraction and multiplication fractions	There is no instruction no tutorial and nothing indicate how to play game and that mean there is no mechanism factor
3		CandyFactor	It's an educational game designed to teach the fraction	Its teach how to cut the candy there is no any operation in it. Doesn't have fantasy, narrative, mystery, and game value.

4		Monkey Tales	It's an educational game designed to teach some math operations	It is difficult to children join the game because they have do some instructions before they started and don't have fantasy, and narrative factors
5		PlayKids preschool cartoon	The provide a videos and games for entertainment and education	The game missing the sociality factor
6		ABC Mouse early learning	This game designed to develop children math skills.	The game get more difficult and more confused when the children going to another area of game and no mechanism and fantasy factors
7		Math your teacher.com	The game designed as a tool to help the teacher to improve student math skills.	The game doesn't have the narrative, mystery, and freedom.
8		iTooch middle school	The designed to middle school student is a new and fun way for learning and practicing.	The absent of narrative, and fantasy factors.
9		Desmos graphing calculator	This game teach the student how to convert the mathematics equations as a graph.	The game need more instructions to lead the student how to play and the missing factors are the instruction, mystery, fantasy, and narrative.

10		Bedtime math	This game goal is to swap the bedtime story with math problem	The goal of game is not clear. the important factor (game goal) is missing

So from Table 1, concluded that all 10 games have one or more missing factors that make these games weak or boring and that will let children leave this type of games (educational games) and going to the entertainment games because it provide all factors of entertaining.

2.11 Summary

The review section surveying the literature includes information on game-based learning courseware research, which enabled the collection of much of the information and intended requirements in this research field. The literature provided material on youth courseware and mobile technologies, edutainment software, educational uses of videogame techniques, and game-based learning and design. Associated reporting in the literature enabled this researcher to wholly appreciate the field, and to better comprehend the system of research methods and applications. Moreover in the literature review we can see the important of education and how we can exploit the technology to be a tool for learning and pleasure in same time especially for children. The review was highly instrumental in the initial gathering of the required data and information for the research field.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

Since this research falls under design research, a well-known design research methodology is adopted. Design research methodology can be separated into two areas. While one area involves studies on the design procedure (Van Aken, 2007), the other is related to investigations on the developed design itself (Vaishnavi & Kuechler, 2015). Both of these phases are part of the hypothetical configuration of design research methodology. Subsequent to research on a design, it is essential that the results acquired be scrutinized in a methodological manner (Ardakan & Mohajeri, 2009). Almomani (2012) expresses the opinion that effective solutions to research problems can be arrived at through well-organized research methodologies. The activities conducted by investigators in this domain include the accumulation and processing of data, as well as the utilization of various tools.

3.2 Phases in Methodology

In order to realize the research goals, this investigation will adopt the well-established design research methodology (Vaishnavi & Kuechler, 2015). This frequently employed process places emphasis on fully developed artefacts which include models, procedures and prototypes (Purao, 2002). Awareness of the problem, suggestion and design, development, evaluation and conclusion make up the five phases of this research methodology. These phases are illustrated in Figure 3.1.

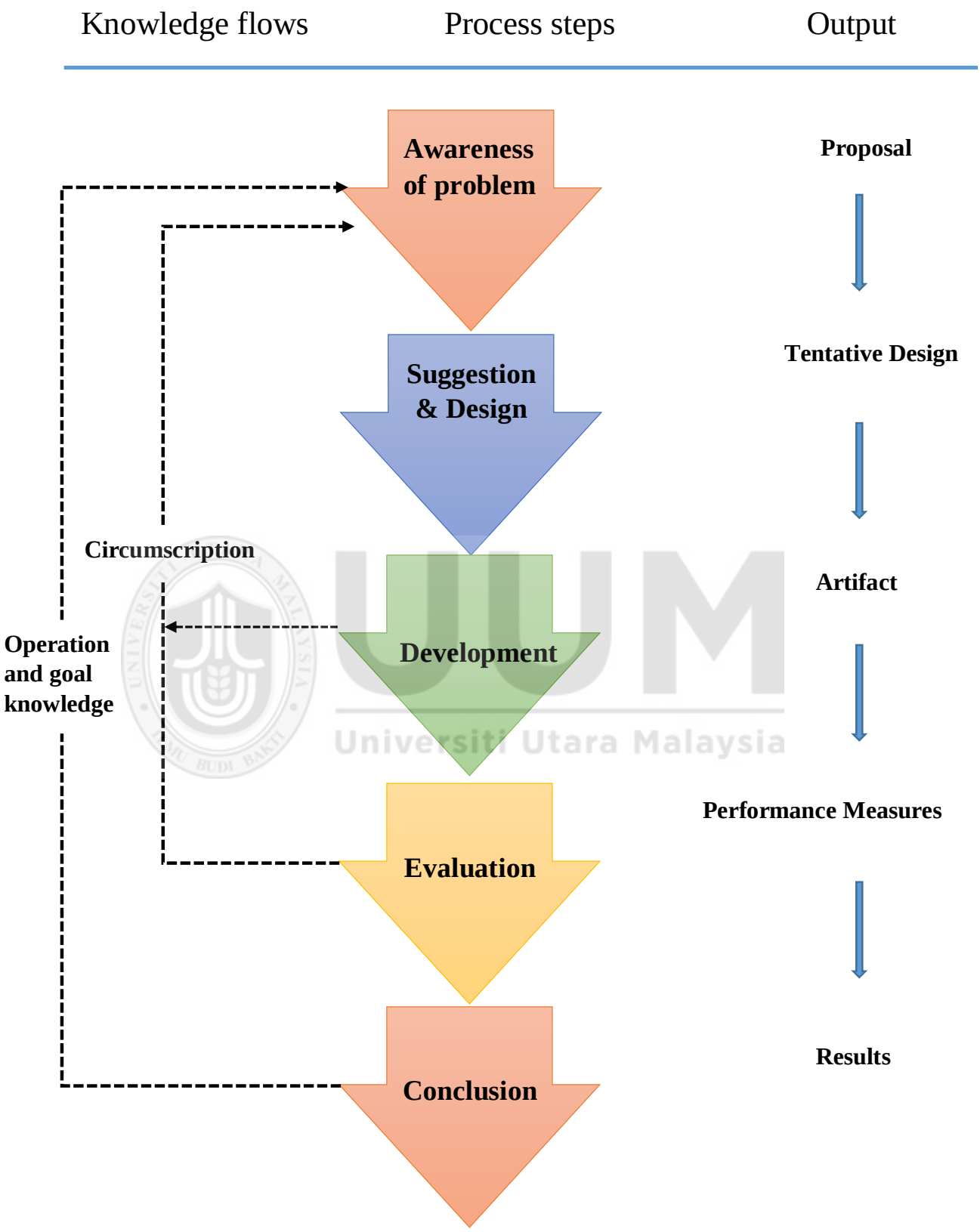


Figure 3.1: The general methodology of the design science research (Vaishnavi & Kuechler, 2015)

3.2.1 Awareness problem

This phase focuses on the identification of the problem through information gathered from relevant literature, a preliminary investigation on existing apps, and data gathering. The main focus of this endeavour is to provide an appealing educational process for primary school students in the form of games. However, this is easier said than done as unlike regular games, educational games lack the element of entertainment to hold the attention of a student undergoing primary education (Fairclough, 2004). This circumstance hinders the development of a learning process that is both effective and interesting. As stated in Chapter One and portrayed in Figure 3.2, investigations in this area (game-based learning) led to the establishment of research questions, objectives and study scope.

3.2.1.1 Literature review

A literature review serves to pave the way towards the achievement of our research objectives by enhancing our general comprehension of this subject and the research problem in particular. In view of this, the researcher into related literature and gather the information required for developing an innovative form of edutainment for students attending primary schools.

3.2.1.2 Preliminary study

A preliminary exercise was conducted to accumulate information on math games (particularly those available through mobile devices) and the association between children and learning processes in relationship to such games. Two activities were conducted: 1) review of selected educational math games; and 2) interview with teachers. Other than an evaluation of several mobile device educational math games, the role of parents in this area and the flaws that come with these games were

identified using gamer's reviewer. Literature review was conducted and game review was performed by playing 10 games as presented in chapter Two. The review is performed by looking at the factors by Shi and Shih (2015) in the games.

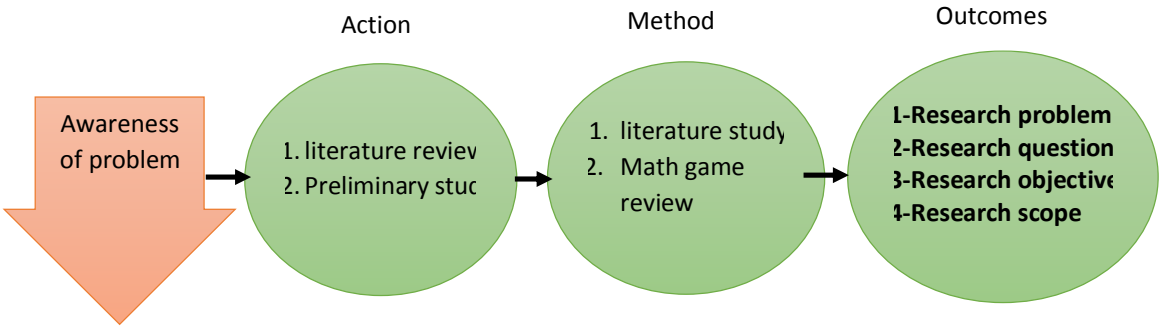


Figure 3.2: Awareness of problem Phase

3.2.1.2 Data Gathering

Data gathering involved setting up interviews for gathering useful data related to the study (Dass, 2014; Huda Wahida, 2013; Hoffer, George, & Valacich, 1999). Three teachers, from Sekolah Kebangsaan Mergong, Alor Star, Kedah, Malaysia (refer to Figure 3.3) were selected as participants for this endeavour. During the interviews, the open-ended nature of the questions, which were sourced from previous studies (Patton, 2002; Owens, 2014), provided these teachers with the leeway to respond in their own words. With such a format, these interviews paved the way towards the exploration of areas beyond the study scope. The teachers' freedom to elaborate on their answers during the interviews also provided the investigator with the opportunity to garner a wide range of perceptions on the subject matter. With the consent of the teachers involved, their responses were recorded on an iPhone Recorder device. The open-ended nature questions meaning the interviewer give a couple of questions and let the teachers answer with open time and with free thinking and all these recorded by a voice recorder and after that the interviewer will listen again to the recorder and transcribe the answers. The method used in teachers'

interview is content analysis that used to extract useful information such as construct suitable syllabus, mathematical questions, children's cartoon characters and the game environment.

So the teachers' interview help to build the low fidelity prototype by knowing what children like to watch or to play with it and they suggest the students like the girl with veil character cartoon and the environment of this cartoon like a trees, colors, the monkey and the lack of crocodile. So after the interview, the low fidelity sketches is completed and researcher return to the teachers one more time to show them the sketches or wireframe of the game to get their acceptance or any comments that need to be added.

Figure 3.3 One of the teachers during the interview

Other than delving into the knowledge and skills of the teachers, the interview questions also probed their ability to enhance the performance of children through the employment of modern technology. Besides facilitating the accumulation of vital

information, these interviews also played a significant role in (a) supporting previously presented qualitative information, (b) detecting potential stumbling blocks, and (c) distinguishing the essential elements required for developing an effective game model for children mathematics skills.

3.2.2 Suggestion and Design

During this phase, the recorded information gathered from relevant literature as well as from the preliminary study and the interview are utilized for crafting of a proposed design for mathematical mobile game that allows children to involve themselves in an entertaining learning experience. This design is to accelerate the learning process and motivate children to learn and also encourages them to learn from their mistakes. Interview with teachers are conducted to gather information on the requirements for such educational game design. The analysis will be done to find out the missing effective game factors from the 10 games. The low fidelity prototype are designed using wireframe technique (Ko, Jung, Kim, & Keum, 2014), Figure 3.4 depicts the activities in this phase.

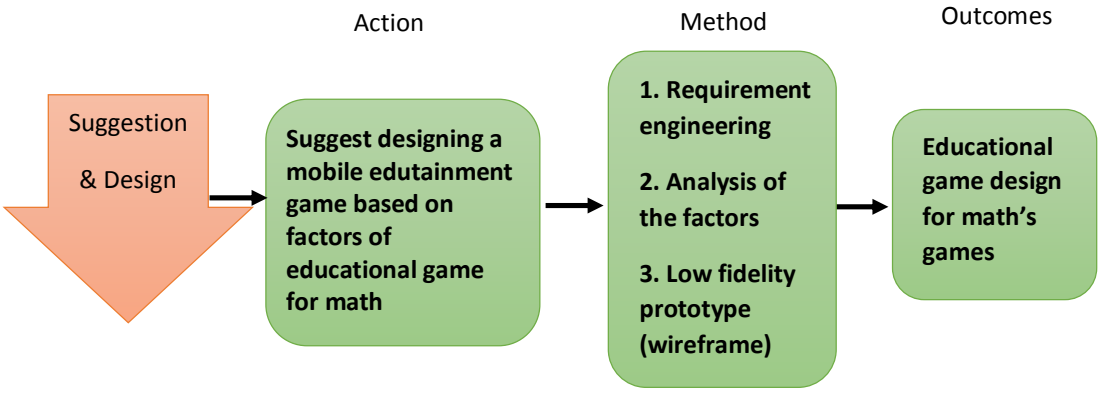


Figure 3.4: Suggestion and Design Phase

The teachers said the challenge factor is typically requires player abilities such as accuracy and quick thinking, which motivates players to achieve their goals. The

mystery and freedom are the special factors only existent in games, and they are the main reasons why children enjoy in traditional game. So player curiosity or exploration will get it from mystery factor and the choosing operation or changing the question will give to children the freedom factors. The way that get the student attention it's to learn them by pictures or sound. So the teachers suggested the game environment like picture, characters and audio effects can make a game more attractive and this can get it from sensation factor. All students like the mobile game because it is provide the interaction. For our game the interaction factor will be touching the screen and choosing the questions or level.

3.2.3 Development

The generation of the recommended game is based on activities that include the development and implementation of the prototype which were carried out during the earlier phases. See Figure 3.5.

3.2.3.1 Rapid application development (RAD)

The fundamental goal of a design is to make available the usage of a trouble-free app. This investigation settled on the rapid application development (RAD) approach for the development of the mobile learning model. RAD is a software generation procedure that incorporates iterative development and software prototyping. Whitten, Bentley and Dittman (2004) describes it as a blending of several structured methods (particularly those associated to data-driven information engineering) and prototyping procedures for the purpose of quickening the development of software schemes.

RAD frequently relies on structured methods and prototyping for identifying user needs as well as for conceiving the ultimate scheme. Subsequently, the data and

process models are upgraded through prototyping to validate the requirements. The iterative replication of these steps culminates in "a combined business requirement and technical design statement to be used for constructing new systems" (Whitten, Bentley, & Dittman, 2004).

3.2.3.2 Prototype development

This study focuses on apps that exploit android platforms (Shihab, Kamei, & Bhattacharya, 2012). These apps are readily available through most mobile devices including smart phones and tablets. Eclipse is described as an accommodating situation for open source software development. Written in Java, it is designed for the development of apps deriving from a similar Java language and setting. Eclipse is considered a secure environment for the integration of a wide range of projects while allowing for the inclusion of a high number of files that come with these projects. The accomplishment of a fully developed prototype is followed by the gathering of real world data. Upon arrival at this stage, it is expected to realize the second objective of this study which is the designing and development of a children's mobile edutainment math game.

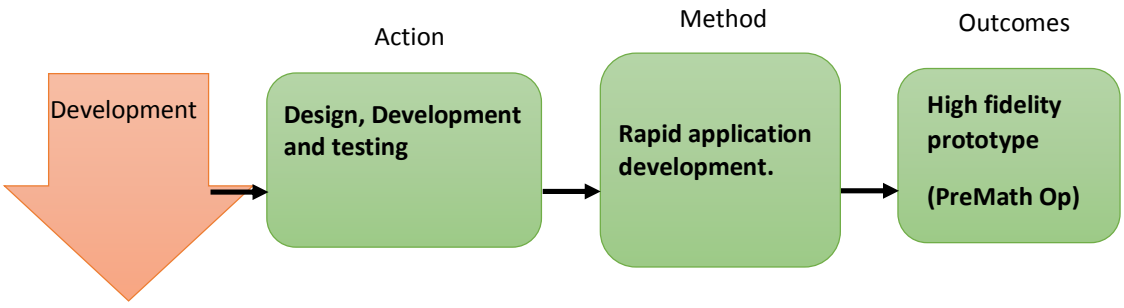


Figure 3.5: Development Phase

3.2.4 Evaluation

The evaluation of this study focuses only on evaluating whether or not the educational game design, which is based on Shi and Shih (2015) and teachers perspective and pedagogy, is usable for children to learn basic mathematical operations. Hence, the high fidelity prototype's usability is measured. Among many procedures for evaluating usability, user testing has proven to be the most practical (Nielsen, 2012). The three requirements for this procedure are (a) the availability of representative users, (b) the execution of representative tasks by the users, and(c) the monitoring of user behaviour for the identification of easy usability and difficulties in relation to interface usage (Nielsen, 2012). The main reason for enhancing usability is to elevate the level of effectiveness (Sharp et al., 2007) as cited in (Hourcade, 2015). Effectiveness in terms of user experience has to do with the degree of accuracy and the extent of an individual's achievement during the performance of a technological task and this is more applicable to technologies generated to accommodate children where a lower level of efficiency can be traced to a lack of accuracy (Hourcade, 2015). This study evaluates usability by looking into three components of usability as outlined by International Organisation for Standardisation (ISO) (1998): effectiveness, efficiency, and satisfaction.

The evaluations will be conducted by observing the children and interviewing the teachers. In order to assess the prototype's level of usability, the interaction between six children and the prototype (Nielsen, 2000; Chamberlin, 2003) were obeserved. The observation included collecting useful data from observing children when they are interacting with the prototype and interviews with teachers (Chamberlin, 2003). So these children, whose age ranges from seven to nine years old, are students of Sekolah Kebangsaan Mergong, a Malaysia national school. The observation process

will be adopted from Ismail, Diah, Ahmad, Kamal, and Dahari, (2011); Diah, Ismail, Ahmad, and Dahari, (2010) and analysed to determine the usability of the prototype for promoting the mathematical proficiency of children in primary schools. With this analysis, the third objective of this study is realised. Figure 3.6 illustrates the process.

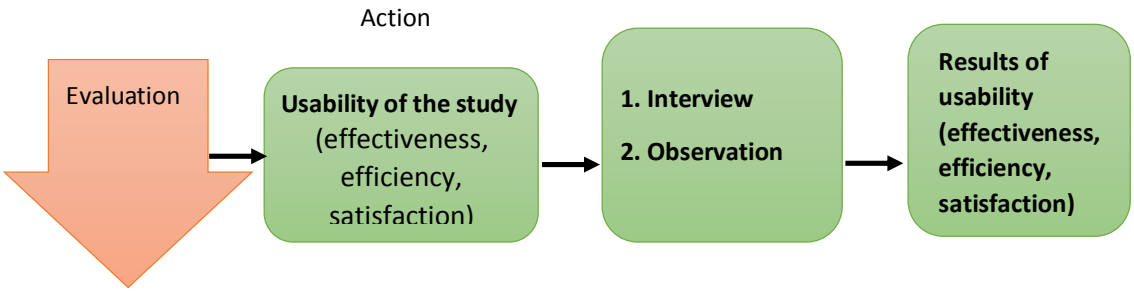


Figure 3.6: Evaluation Phase

3.2.4.2 The Usability Test

A usability test was carried out for the purpose of evaluating and determining the value of a generated item (Taheri, Alemi, Meghdari, PourEtemad, & Basiri, 2014). According to Nielsen (1994), although the application of an appropriate testing scheme does not call for a great deal of guidance and support, it can nevertheless be highly effective and successful for ascertaining the user-friendliness degree of computerized instruments. The usability test, which is governed by the criterions of effectiveness, efficacy and satisfaction, focuses on the gathering of impartial data to evaluate the accessibility of a system, and the feasibility of its presentation through mobile devices or other means.

A usability test can be considered as effectiveness, provided its results clearly demonstrate whether users can use the application freely, whether they enjoy using it and if the application helps users improve their performance. At the same time, an efficacy usability test should measure whether the application is useful for doing a certain task. Furthermore, the satisfaction usability test should provide the information on the users' attitudes towards the prototype functioning (Thompson, McClure, & Jaeger, 2003). The usability test can be conducted in many ways based on the data collection and data analysis methods. For example, Adil (2015), conducted the usability test by means of interviews with total of 10 teachers as well as doing the questionnaires with 5 autistic children between the ages of 5 to 7 years. Al-Wakeel, Al-Ghanim, Al-Zeer, and Al-Nafjan (2015), conducted the usability test into three main parts. The first part was based on the Eye Tracking usability measurement tool; second part was based on observation and the third part was depended on questionnaires with a sample of 14 children, 8 autistics and 6 non-autistic children. The second part also divided into two sections: the first section depended on manual observation when used an eye tracker as measurement tool and second section was automatic observation using Morae usability-testing software. In additional, (Ismail, Diah, Ahmad,, Kamal, and Dahari (2011), conducted the usability test by means of interviews and questionnaires with total of 5 children two of them were five years old and another three were six years old. The usability tests were conducted by means of observation and interviews as suggested by Ismail, Diah, Ahmad, Kamal, and Dahari (2011). The participants of this usability study included three teachers and six children aged 7-9 years old from Sekolah Kebangsaan Mergong at Alor Setar, Malaysia, Thus, this study also conducted interview and

observation to perform usability test on users. At this stage, the study had accomplished objective three.

3.2.4.3 Procedure description

The procedure for this investigation emphasizes on observations and interviews. In order to amplify the supporting data and enhance their levels of accuracy for determining app usability interviews were conducted on the aforementioned three participating teachers. Some examples of questions used for the interviews and questionnaires can be observed in Figure 3.7 (Ismail, Diah, Ahmad, Kamal, & Dahari, 2011).

Screen / Evaluation element	Child 1	Child 2	Child 3	Child 4	Child 5
The child do not have trouble to navigate using keyboard					
The child do not have trouble to find the start menu					
Graphics used on the page attract the child					
Music used attract the child					
Size of the game window opened is good enough					

Figure 3.7 The sample of observation item from (Ismail, Diah, Ahmad, Kamal, & Dahari, 2011.

During the interviews, the open-ended questions posed to the teachers provided the researcher with the opportunity to explore areas beyond the parameters of the subject matter (refer to Figure 3.8). With approval from the teachers concerned, these interviews were recorded on an iPhone device (Cohen & Crabtree, 2006). The teachers were queried on the conditions that they feel ought to be in place prior to the

provision of assistance to children mathematic material difficulties. Such information goes a long way towards the fashioning of an effective app design. The replies received during the interviews will serve to provide investigators with a general idea of the teachers' perspective regarding this app. These interviews can also be a source of constructive information regarding the relevancy of the model to children. The observation process began with the fitting of the PreMath Operations app in a Samsung Galaxy 7 mobile device model with an Android operating system version 4.2.2. The teachers were directed to guide the children on the appropriate way to make the most of the PreMath Operations app see Figure 3.9.

While the children were allowed full control over the device, the teachers were readily available to assist whenever necessary. Figure 3.10. This study necessitates the attendance of the investigator at the school several times over the period of a fortnight. On these occasions, each child is allotted a period of between 10 to 15 minutes to utilize the app (Hussain, Mutalib, & Zaino, 2014). During this time frame, the investigator observes the interaction between the child and the PreMath Operations app. The average observation period is similar to the average time required by a child to complete the activity presented by the app (Patton, 2002; Ismail, Diah, Ahmad, Kamal & Dahari, 2011).

Upon the expiry of the observation period, the responses of the participants were documented. The emphasis of this usability test was primarily on gauging the elements of effectiveness, efficiency and satisfaction by the ISO 9241-11 benchmark set by the International Organization for Standardization (Ismail, Diah, Ahmad, Kamal, and Dahari, 2011; Abdullah and Ismail, 2014 ;Tahir and Arif, 2014). The accumulation of all data related to this investigation was realized through

observations and interviews. A discussion on these data as well as the test results is provided in Chapter Five.

Figure 3.8. Teachers being given instructions on the use of the PreMath Operations App

Figure 3.9. The teacher give the instructions on how to use the new App

Figure 3.10. Two of the participants interacting with PreMath Operations App

3.2.4.4 Sampling for usability test

This investigation relied on data acquired through observations and interviews for the execution of usability tests. Jacob Nielsen (2000) suggested that reduced sample sizes are preferable as they are more economical. This is attributed to the reality that the expenditure for testing rises in tandem with increases in the number of participants engaged for a study. In view of this, this investigation limited the number of child participants to six. The ages of these children ranged between 7 to 9 years ((Dunning, Holmes, & Gathercole, 2013). The intention to maintain costs at an affordable level also prompted the restriction of the number of teacher participants to three (Chien, et al., 2015).

3.2.4.5 The gathering and examination of data

The data accumulated were derived through interviews and observations. The participating teachers were observed during their utilization of the PreMath

Operations app and subsequently interviewed. Data from these interviews were then examined to evaluate the teachers' understanding and outlook with regards to this app. During the testing process, the children were given the freedom to utilize the instrument for the performance of tasks. Each child was allocated 10 to 15 minutes to realize the completion of a specific task.

A task list was adopted from Ismail, Diah, Ahmad, Kamal, and Dahari (2011) to assess the ability of a child to complete a task within the given time. The word 'Yes' on the task list denotes the successful completion of a task, a 'No' denotes an uncompleted task, and a 'Partial' denotes the rewarding of consolation points for an unsuccessful, but praiseworthy attempt. Subsequent to the observation phase, the investigator interviewed the children with questions derived from a comparable study conducted by Ismail, Diah, Ahmad, Kamal and Dahari (2011).

3.2.4.6 Analysis Techniques

The following steps make up the data analysis process;

Step 1: Complete observation and gathering of data based on efficiency, efficacy, and satisfaction.

Step 2: Preparing the summary table for efficiency, effectiveness, and satisfaction.

Step 3: Calculating the effectiveness rating according to Ismail, Diah, Ahmad, Kamal, and Dahari (2011). This can also be seen below:

Effectiveness (%) = (Yes = (Partial x 0.5)) / Total x 100%

Step 4: Calculating the efficiency rating according to Ismail, Diah, Ahmad, Kamal, and Dahari (2011). This can also be seen below:

Efficiency (%) = (Yes = (Partial x 0.5)) / Total x 100%

Step 5: Calculating the satisfaction value based on the formula below (Ismail, Diah, Ahmad, Kamal, & Dahari,2011).

Satisfaction (%) = Answer Point / Total Point x 100%

Step 6: Calculation of the usability rating will finally be done and computed based on the following formula (Ismail, Diah, Ahmad, Kamal, & Dahari,2011).

Usability (%) = (Effectiveness + Efficiency + Satisfaction) / 3 x 100%.

3.2.5 Conclusion

In this phase, we will write a report includes children feedback on the effectiveness of the games. After that we will document the result finally print the final report. See Figure 3.11.

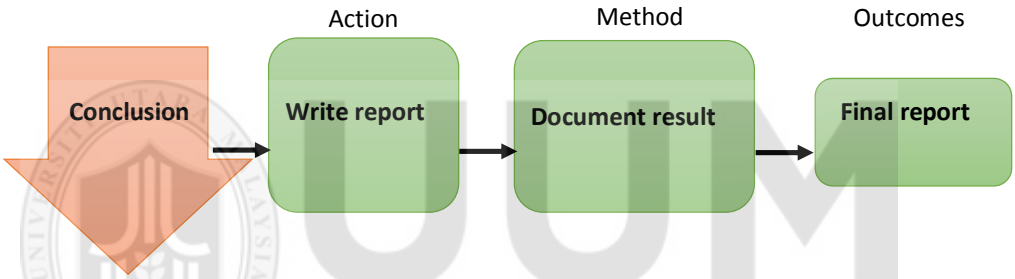


Figure 3.11: Conclusion Phase

3.3 Summary

This chapter describes the methodology that used it in our study and it was composed from five phases: awareness of problem, suggestion, development, evaluation and conclusion. All phases aim to achieve the objective of our study.

CHAPTER FOUR

PROTOTYPE DEVELOPMENT

4.1 Introduction

The development of the prototype, PreMath Operations mobile application is presented in this chapter. Moreover, the function of the prototype with user interface design according to the proposed design is described in this chapter. The Android environment is used by the application. This application has been implemented using the Java programming language, and the Adobe Photoshop CC application for graphic design purposes.

4.2 Game factors and its elements

The model by Shi and Shih (2015) presented factors on how to design useful digital game-based learning. It also explained the 11 crucial game-design factors such as game mechanism, game goals, game value, game fantasy, freedom, interaction, sensation, narrative, sociality, challenges, and mystery to help educational game designers come up with interesting games. Table 4.1 shows that game-based learning category can be divided into two – game factors and elements. As can be seen in Chapter Two, game factors are derived from Shi and Shih. The elements column is used to refer to the effective factors of game design.

Table 4.1 Shi and Shih (2015) model factors

Game Based Learning (GBL) category			
Game factors			**Elements**
Game goals	Game value	Challenge	Challenge is a players' effort that achieve goals. It is exert a positive effect on the cognitive and affective outcomes of learners but require skill-level adjustment for players.
		Sociality	Social behavior within a game can be divided into communication, cooperation, competition, and conflict.
		Mystery	The mystery is a key gaming feature, which involves player curiosity or exploration.
	Game fantasy	Narrative	Using a game to tell a story poses a substantial designer challenge, similar to making an effective movie.
		Sensation	Presents the virtual world to players, including audio and aesthetics
	Game mechanism	Interaction	Involves the game environment and background. Game designers construct the virtual world image

			through the game system, which includes stories and multimedia, and an entire worldview.
		Freedom	Refers to how many actions players can perform in the game system and how many individual services they can use.

In this study, the researcher designed an edutainment game using the factors from the Shi and Shih (2015) model and the viewpoints given by three teachers from Sekolah Kebangsaan Mergong, Alor Setar, Kedah, Malaysia. The PreMath Operations mobile application is designed to help in learning and of the basic mathematical operations for children, specifically Malaysian children of ages between 7–9 years old.

Fundamentally, the PreMath Operations is a combination of all 9 factors from Shi and Shih (2015) with specific characteristics adapting to the teachers' viewpoints on learning mathematics according to the syllabus and game review conducted in previous phase of research methodology. Various degrees of challenge are provided at playing mode, i.e., the child must answer and solve the questions. The game's mystery lies in discovering more stages. The game sensations come from the game images. The freedom comes from giving the user a chance to change the operations and the questions if they are too difficult. The interaction factor comes from the buttons and the instructions provided by audio records such as the instruction "Tap on the crocodile". Thus, the PreMath Operations application is able to provide entertainment and education while alleviating the perceived dull and uninteresting

parts often associated with the learning process. Table 4.2 show PreMath Operations category.

Table 4.2 GBL factors design strategy for designing educational mathematic game for children.

Game Based Learning (GBL) category				
Game factors			**Design strategy (Specific characteristics)**	**Supporting authors**
Game goals	Game value	Challenge	Challenge must provide positive effect on cognitive and affective outcome. In a math game, the challenge can be presented as having children to solve the equations one level at a time. One can only go to next level if the previous level has been completed successfully.	J. P.Gee, (2003) , Owen, (2004)
		Mystery	Mysteries should be provided so that players would anticipate what happen next. Thus, the game should provide some mysteries to the children so that they want to see next question is. For math educational game, the next question or next operation to be presented should consider what has been designed in the syllabus so that the game is aligned with the subject's learning objectives.	Garris and Ahlers, (2001), Griffiths, M.N.O.Davies, and Chappell, (2004), Billieux and M. Van der Linden, (2013)

	Fantasy	Sensation	The game should provide images of cartoon characters in order to give students the feeling of playing rather than the feeling of learning. For a mathematic game, cartoon-like characters that student prefer should be provided to help increase engagement and this character can be obtained from the teachers or the students themselves.	Choi, J. Huang, and Baek, (2013)
	Game mechanism	Interaction	The game should allow for numerous interactions, such as touching interesting objects, feedback, praises, and other functions necessary. Students should have the control of the game thus interactions should be easy especially when designing children.	Coutinho, Galv˜ao, BatistaJr., Moraes, and Fraga, (2015)
		Freedom	The game should provide players the freedom of choosing mathematical operations that they want to learn (play) and they are allowed to change the questions if they find it difficult to be solved	Teng, (2010)

4.3 Narrative and Sociality

For narrative factor, it is useful when dealing with mathematical problem solving. This will involve designing a game for higher level of students, for example Level 2 (Tahap2) students in primary schools or secondary schools. Questions in the higher order thinking skills HOTS category could also be best incorporated with suitable narrative for ease of understanding and stimulation (Kiili 2005). Sociality means the communications and cooperation between game players. For math game, it depends on the level of the learner (i.e. the player). For young learners learning basic math

operations, sociality could be a distraction rather than focusing on solving the equations (Wu, Wang, and Tsai, 2010). Thus, these two factors were excluded from our design.

4.4 Low fidelity prototype design

This concept typically refers to a prototype that is sketchy and incomplete. It usually possesses some of the target product's characteristics, but is still otherwise simple. Usually, this is made to produce the prototype and test broad concepts faster. The design of the researcher's low fidelity prototype was based on the interview with the teachers. To improve the game attribute, the interview with the teachers from Sekolah Kebangsaan Mergong in Alor setar focused on identifying the characters and games that the children preferred.

Figures 4.1 and 4.2 show the hand drawing images, often referred to wireframe to produce the design based on the teachers' interviews. In the home page, the player can first choose the language and the game level. After these selections, the player is directed to a new page that displays the number of stages. The player must first choose stage 1 and answer every question completely. Once all the questions are answered, the player will be allowed to proceed to stage 2.

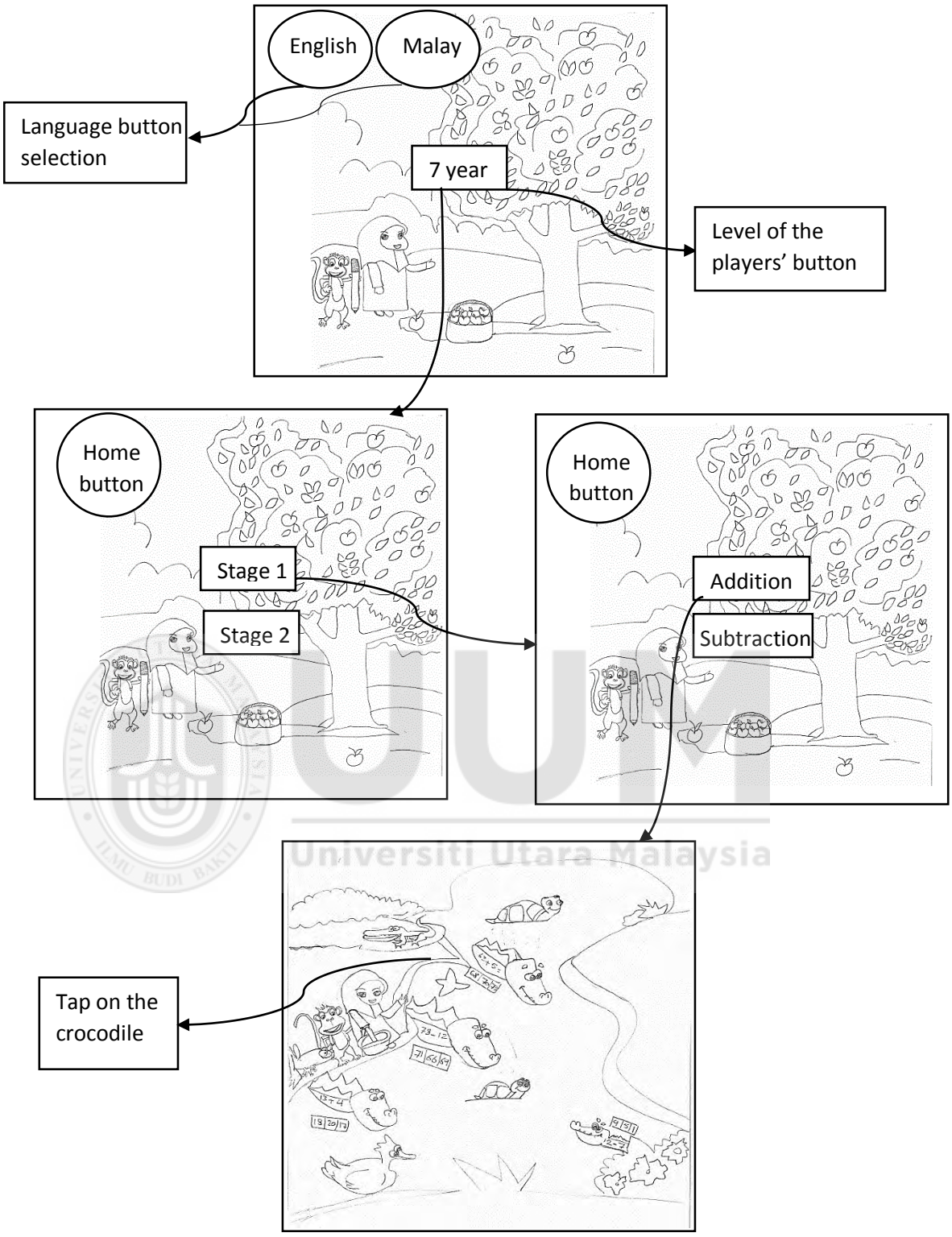


Figure 4.1 The sketch of the first stage

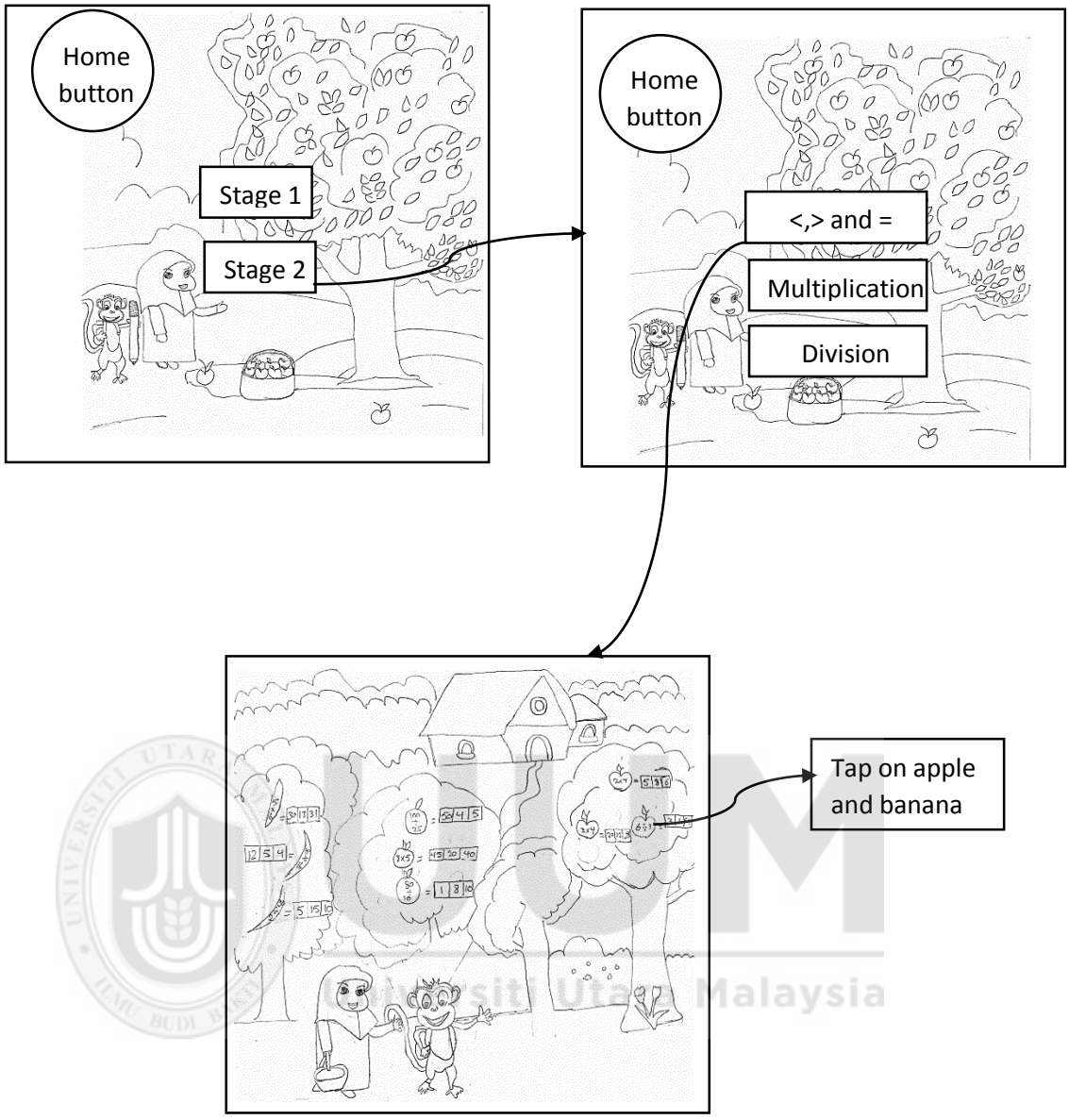


Figure 4.2 The sketch of the second stage

In PreMath Operations app components the challenge factor is the first factor that considered in designing the prototype because it usually associates with the teaching and learning objectives. So the PreMath Operations provide the challenge factor by leading the students to solve the equations and complete the game. For mystery factor the PreMath Operations provide some mysteries to the children so that they want to see what the next question is and what the next stage is. However, PreMath Operations did not provide the narrative in playing game mode because the students

will need the explanations form their teachers or parents and the goal of game to provide learning with no external help. Images of cartoon and sounds provided by the game will give the players feeling of playing rather than feeling of learning and this will be the sensation factor. The PreMath Operations did not provide sociality factor because of student is too young. For a math game, the sociality factor can involve a simple interface for communication or for players to battle with each other that would make it more interesting but it is the teachers' concerned that it would be more of a distraction for young learners that they would minimize their learning. The goal of the game is to focus on teaching the basic of mathematics material. The PreMath Operations provide the interaction and freedom factors by make the players interact with screen through touching, feedback and inserting objective and give to them a freedom in choosing the operation and changing the questions.

4.5 High fidelity prototype

This section will give a description of the Premath Operations mobile application. Based on the recommendations from the teachers' interviews, it was determined that the designs should include more multi-modal features and rely less on textual modality in order to more appealing for the children.. Sound effects during interactions were also suggested. They pointed out that these effects would capture the user's attention. By examining the 10 games mentioned in chapter 2, the research attempted to address the major missing factors by applying the Shi and Shih (2015) model to derive a design strategy as presented in Table 4.2. The sketch was designed based on the information from the low fidelity section, the teachers' interviews, and the Shi and Shih model. For graphic design purposes, the sketches were converted using the Adobe Photoshop CC application.

4.5.1 Home page

The research aims to present a game design that considered all the factors mentioned in the Shi and Shih (2015) model. The Premath Operations application is available in two different languages: Malay and English. The Malaysian language was set as the application's default language. The Premath Operations application has an interface that allows the user to choose the preferred language. The user can switch languages by touching one of the two flags and choosing a specific language button. The first flag represents the Malaysian flag – touching it will select Malay, while the second flag is the British flag and this corresponds to the English language.

Furthermore, the interface of the Premath Operations application has three core functions that represent the mathematical learning level according to the syllabus. The student's age is matched with each level. So when using the English language, the interface will display 7 years, 8 years, 9 years, while in Malay language, the display will show 7 Tahun, 8 Tahun, 9 Tahun. The student can then choose every function of the application by selecting the appropriate icon depending on the student's age and the desired level of the application. Figure 4.3 show the home page.

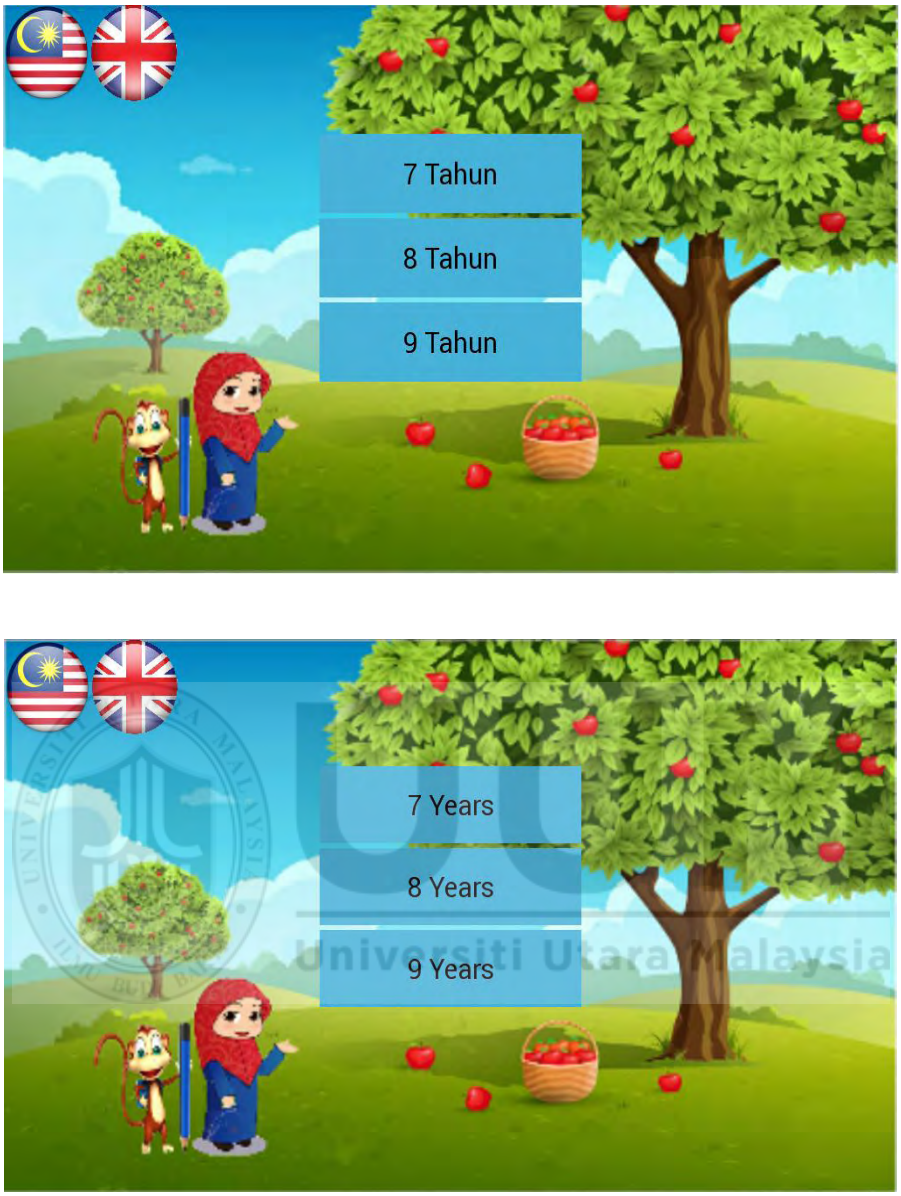


Figure 4.3 Home Page of Premath Operations

4.5.2 **Levels of application**

This section illustrates the application levels along with their corresponding content. As seen in Figure 4.4, the Premath Operations application has two stages. The first stage contains the addition and subtraction operations depending on the student's level. Figure 4.5 shows how the second stage for 7-year olds has comparisons

between numbers, i.e. what is greater, lesser or equal. For children aged 8–9, there is comparison, as well as multiplication and division operations. The player cannot advance to stage two until the addition and subtraction operations are answered completely. A 7-year-old player who completes the first stage two will be taken to stage two. If the player solves all the comparison questions, a congratulation message will be shown and the game is completed. Consequently, players aged 8 and 9 need to complete stage one and stage two with questions in comparison, multiplication and division in order to complete the game and reach the congratulations page. The level of math operations and the content is based on the national syllabus.

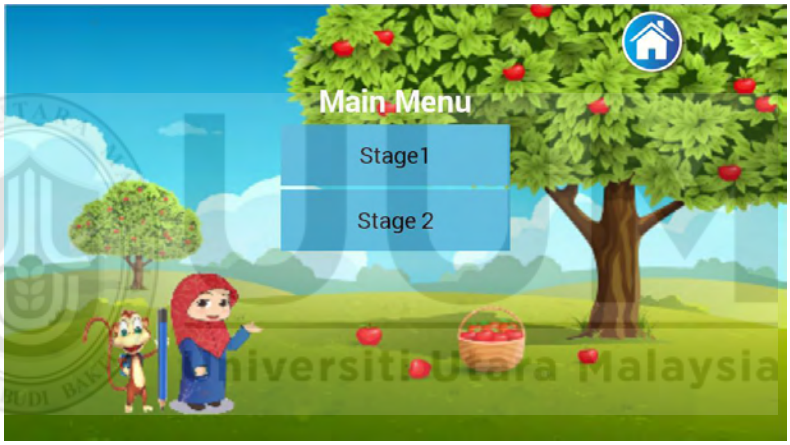
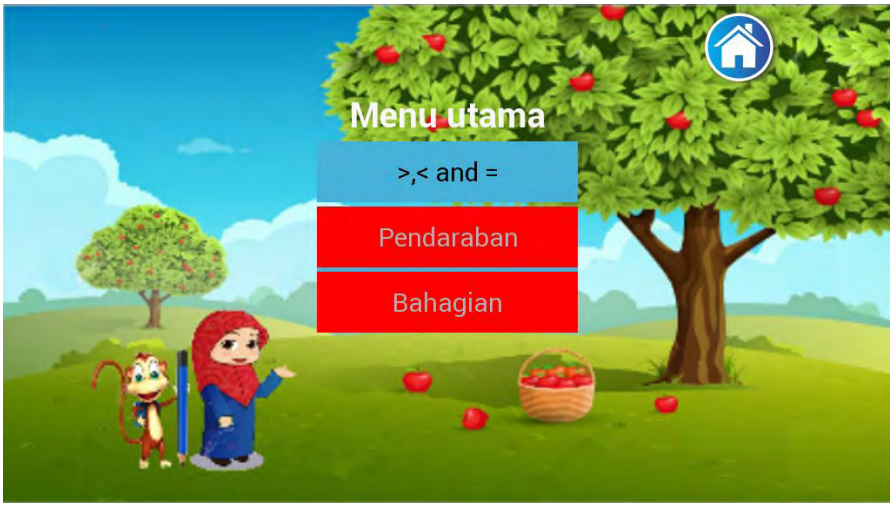


Figure 4.4 showed the stage of application



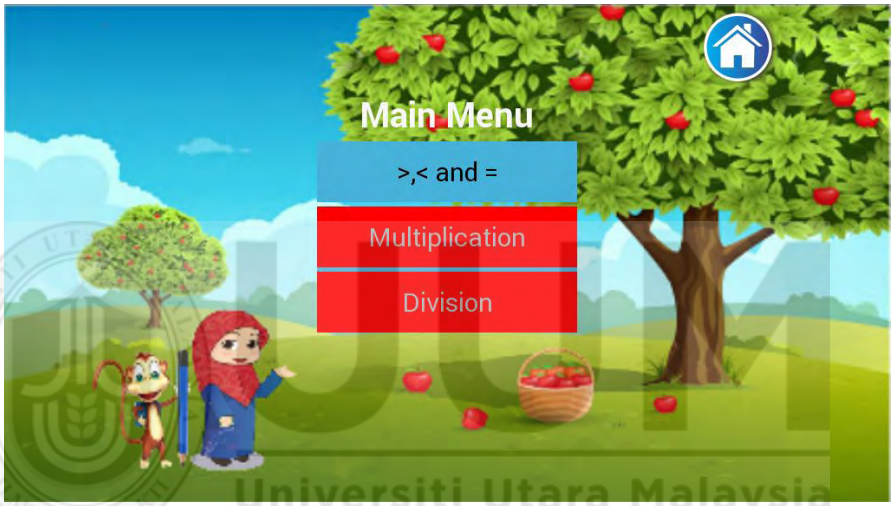


Figure 4.5 showed the second stage for 7 years old student

4.5.3 Playing Stage one of application

1. Seven years old student:

The players need to open the application and choose the button corresponding to 7 years old. Then, they will see a new page that will display the icons for stage one and stage two, as well as the home button icon. When opened for the first time, the player will not be able to select the second stage and it will appear in red, as seen in Figure 4.6.

Therefore, the player will have to select stage one. After choosing stage one, a new page displaying the choices between addition and subtraction operations as well as the home button icon will appear see Figure 4.7.

Figure 4.6 showed student not allowed to select the second stage

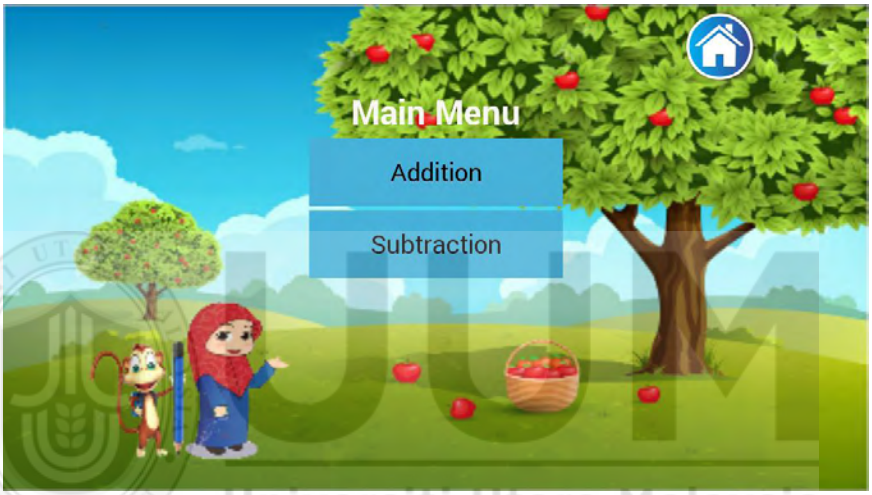


Figure 4.7 showed the stage one content

In order to complete stage one, the student will have to solve the addition operations first and then solve the subtraction operations. Student will be given five questions for each operation. If played in the English language, the player will hear the command “Tap on the crocodile”, while in the Malay language, it will be “Sentuh buaya” see Figure 4.8.

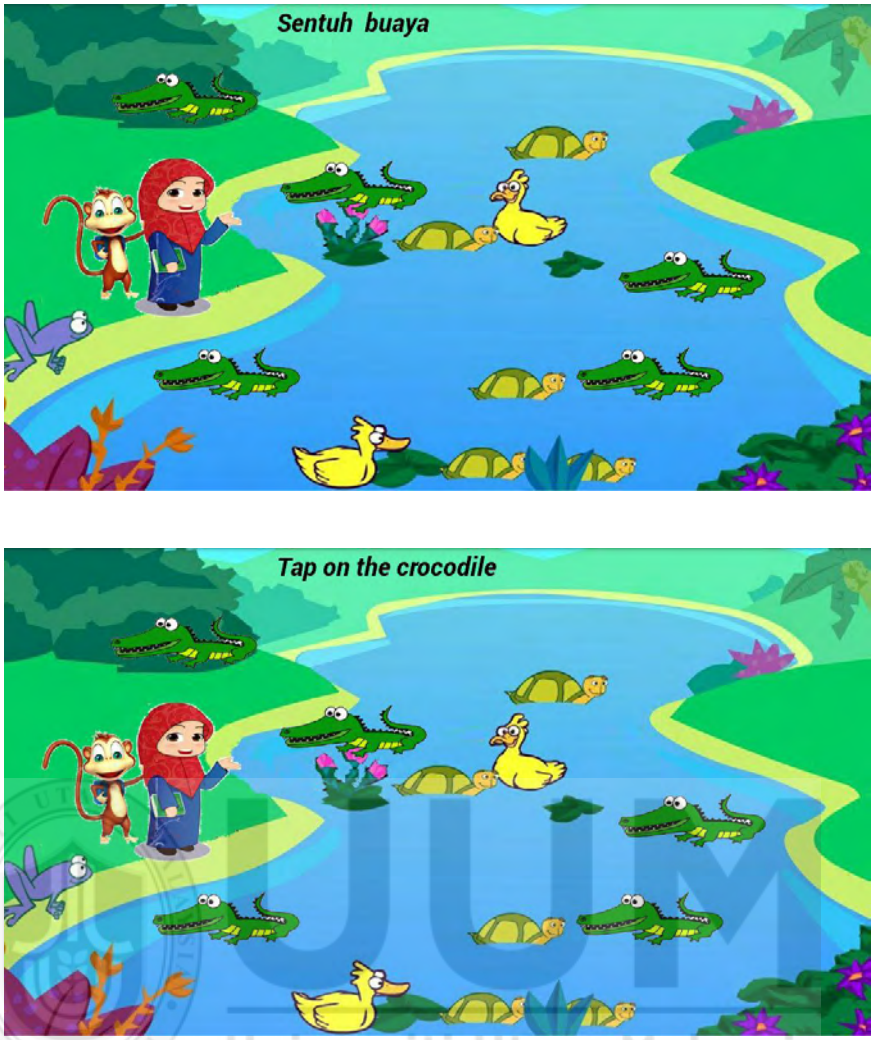


Figure 4.8 showed the addition and subtraction game play

Once the crocodile is tapped, a multiple choice question will appear. If the wrong answer is chosen, the question will remain and a notification saying “Sorry wrong answer” will be displayed. This will be repeated until the player answers correctly (see Figure 4.9). If the right answer is chosen, the question will disappear and the sentence “well done” will be displayed. To start playing the second stage, the student must complete all the questions in the addition and subtraction operations see Figure 4.10.

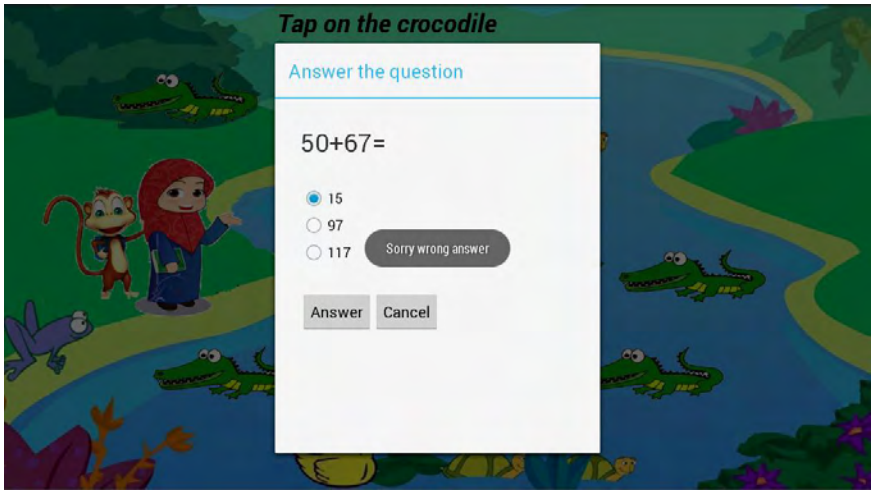


Figure 4.9 showed the wrong answer choice

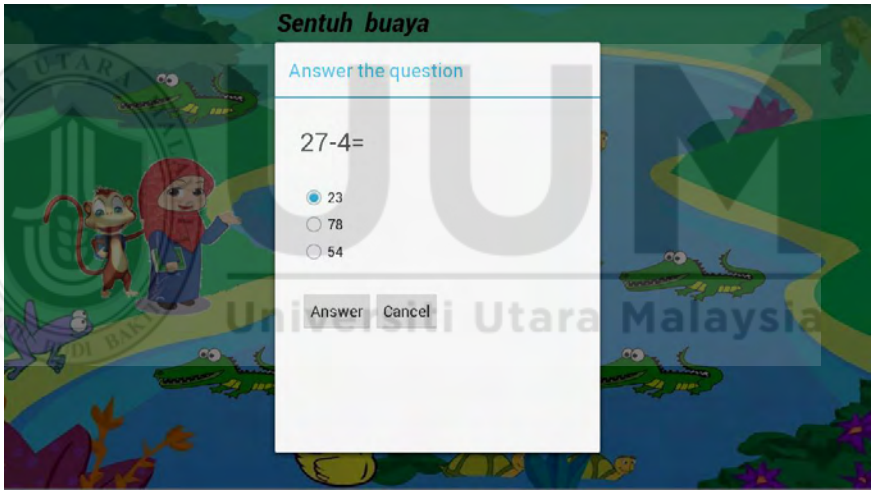


Figure 4.10 showed the correct answer action

2. Eight and Nine years old students

The students will have similar instructions as those from the younger students but the range of numbers will be larger. For students in the first grade, the range is from 1–100, the second grade students will be given 100–1000, and the third grade students will have 1000–10000. The number sizes are based on the Kurikulum Standard Sekolah Rendah (KSSR) syllabus for primary school. Moreover, the number range for each student level will be the same for all stages of the Premath Operations application.

4.5.4 Playing Stage two of application

1. Seven years old students

Once the first stage is finished, the player will be allowed to move on to the second stage and the stage 2 button will be activated as seen in Figure 4.11. A seven-year old player will not be allowed to play with the multiplication and division operations. The buttons corresponding to these two operations will be red. See Figure 4.12

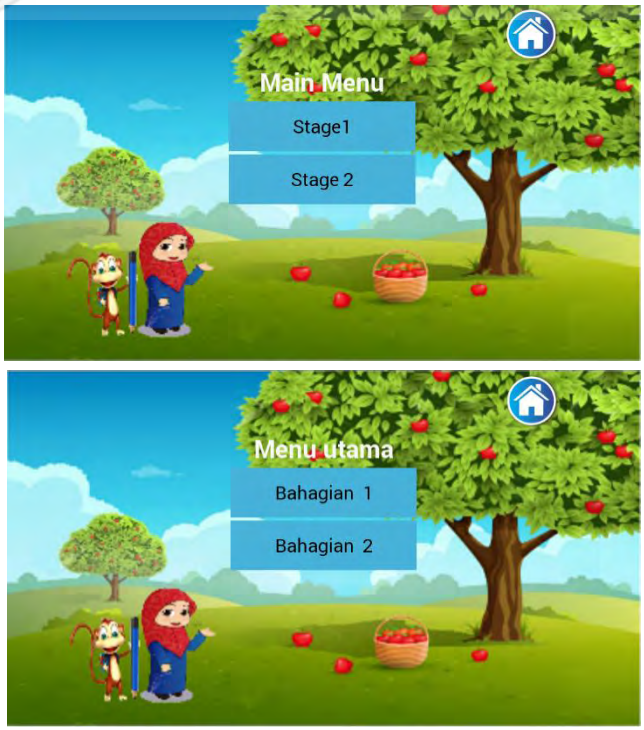


Figure 4.11 showed the stage 2 activation

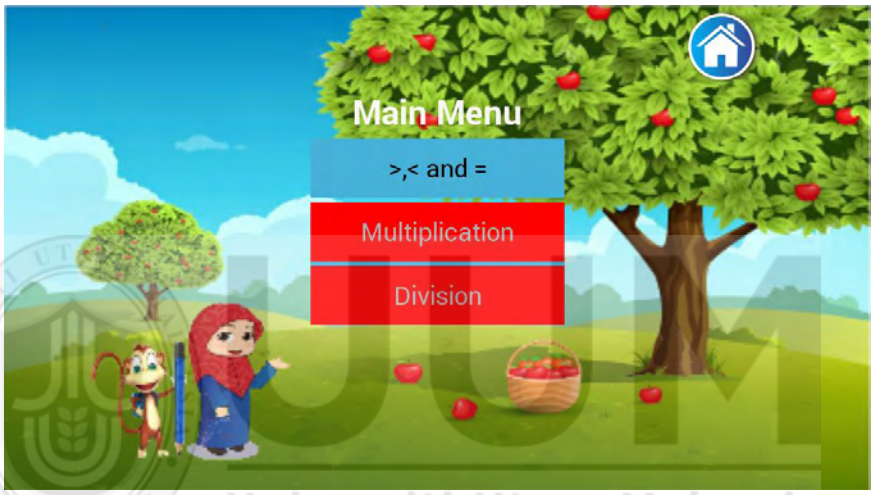


Figure 4.12 showed the second stage for student in even years old

In this stage, the player will hear the command “Tap on apple and banana” if played in the English language while the Malay language will say “Sentuh epal dan pisang” as seen in Figure 4.13. At this stage, the student will solve greater than, less than, and equal to operations.

Figure 4.13 showed the stage two

When the apple or banana is tapped, the comparison question will appear and the students will be given three choices. A wrong answer will result into a prompt saying, “Sorry wrong answer” (see Figure 4.14). A right answer will be indicated by the prompt, “Well done”. See Figure 4.15.

Figure 4.14 showed the wrong answer action

Figure 4.15 showed the right answer action

2. Eight and Nine years old students

To complete the game, the students in this age group must solve all the questions in stage 2. As seen in Figure 4.16, all the buttons corresponding to the operations (comparison, multiplications and division) are active. The procedure is similar to that of the seven-year old students see Figure 4.17.

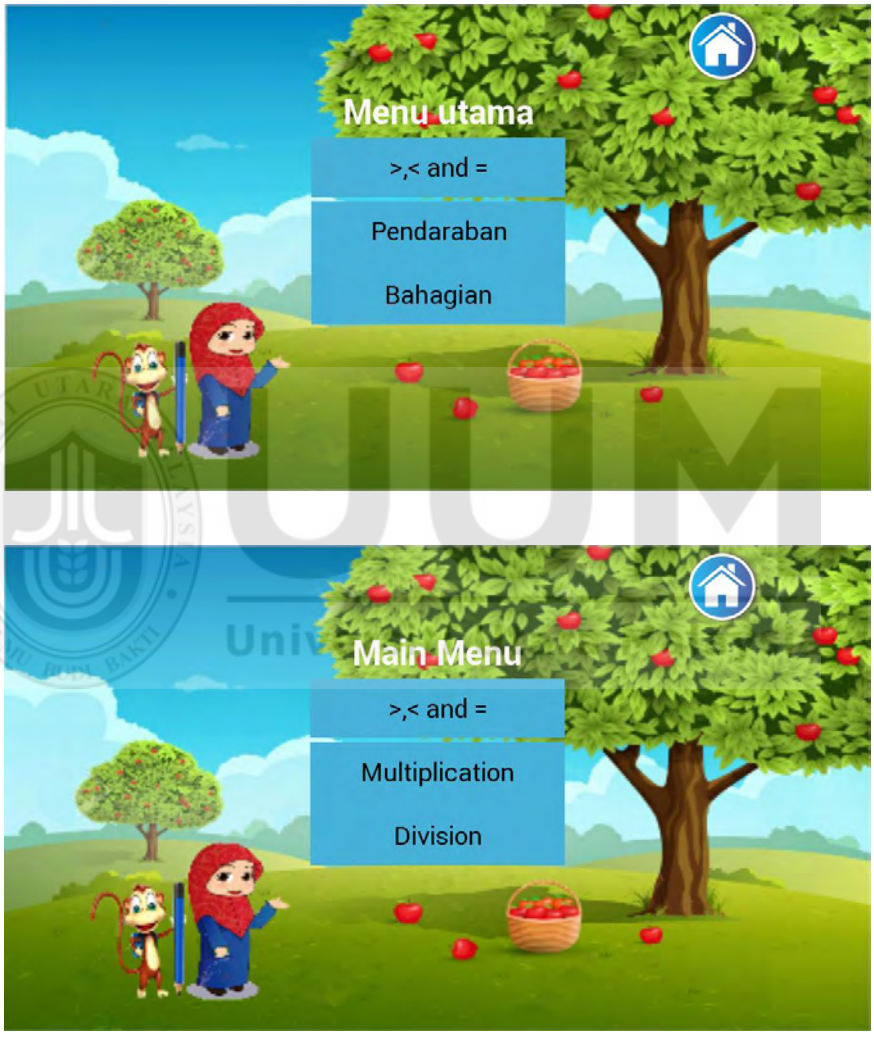


Figure 4.16 showed the activation button for all stage two

Figure 4.17 Showed the right answer action

4.5.5 Game finishing

The last page will appear once all the questions are answered correctly and a voice saying “congratulations” will be heard see Figure 4.18.

Figure 4.18 showed the game completed by player.

4.6 PreMath Operations Application testing

This study makes use of Alpha testing. An alpha test is a preliminary software field test carried out by a team of users in order to find bugs that were not found previously through other tests. The main purpose of alpha testing is to refine the software product by finding (and fixing) the bugs that were not discovered through previous tests. In alpha testing we test our mobile game with quick-and-dirty method, this method will go of recruiting and scheduling time with real users and just test the designs with anyone who’s available. So we put the design in front of the first person we found (who is unfamiliar with the product) and seeing if they can make sense of it. After test the actual functionality we collect the giving feedback (Summers & Watt, 2015).

4.7 Summary

This chapter first discusses the design strategy of the Premath Operations application. The design's specific characteristics classified according to the 11 factors of Shi and Shih (2015) model. This chapter also provide an explanation on the translation of the design into designing a low fidelity prototype, the prototype's interfaces, the manner the prototype should be used, and the levels of the prototype. After having designed the application, a prototype was developed to assist children in improving their mathematical skills.

CHAPTER FIVE

EVALUATION

5.1 Introduction

The evaluation of the PreMath Operations application is also discussed in this chapter. Thus, the study's third objective is met. As outlined in Chapter Three, the usability of the PreMath Operations application was determined by conducting usability tests (Nielsen, 1994). Observations and interviews were conducted to gather data for the usability test. The results were then discussed. The testing process was also explained. The usability test conducted had different procedures. The next sections describe these procedures in detail. The evaluation mainly focuses on the design and not on the evaluation of the children's performance.

5.2 Evaluation Procedure

There are varying procedures for the usability test. These procedures will be described in the subsequent subsections.

5.2.1 Usability Test

Interviews and observations were part of the usability test methods used in this study. Given the design strategy described in Chapter Four, a usability test was performed to measure whether children find the PreMath Operations application effective, efficient, and meet their satisfaction. The interview was conducted at Sekolah Kebangsaan Mergong, Alor Setar, Kedah, Malaysia. Three math teachers were interviewed. These interviews were used to supplement the study, increase the supporting information, and improve the accuracy of the material app's usability data. Furthermore, the observation was conducted on a sample of six children from Sekolah Kebangsaan Mergong, Alor Setar, Kedah, Malaysia.

5.2.2 The Results

This section presents the results obtained from the usability testing and the test cases. Separate discussions were conducted based on the gathered results. Results from the test cases were discussed first, followed by the usability test results. As mentioned previously, interview and observation were utilised in this study's usability test. The result from the interview will be presented first. Afterwards, the results from the observation will be presented.

5.3.1 Results of Teacher's Interview

The results from the researcher's interview with the teachers are discussed in this section. The interview questions focused on the teachers' perceptions about the application satisfy in order to help the children learn mathematics. It also gathered useful feedbacks that can then be applied to the application design. Five interview questions were given to each teacher. The following points summarise the results and discussions from the three respondents:

i. The first interview question was: "How effective is the PreMath Operations app in educating the children with mathematics problem? All the teachers gave positive responses and good feedback regarding the application's effectiveness in educating the children.

ii. The second question from the interview was: "From your perspective, how satisfied were the children with the application?" The teachers responded that the children showed their happiness using their facial expressions. It is observed that the children were holding the smart tablet and they were keen on using it again and again. It was observed that the children found the PreMath Operations application to be appealing. They

appeared to enjoy touching on the objects on the tablet's screen while using the PreMath Operations application's interface. Furthermore, it is noticed that the children were attentive to the voice feedback from the interface.

iii. The third interview question was: "Describe any special responses exhibited by the children while using PreMath Operations and the circumstances at that time." All the teachers stated the children enjoyed listening to the voice feedback and touching/tapping on the objects on screen and viewed that they need the element of play in their learning time. Moreover some of the children solved the equations faster than others because they have the shortest way to solve some equations compared to the others.

iv. The fourth question from the interview was: "Do you feel that PreMath Operations' primary function is that of entertainment, education, or both? Why and how?" All of the teachers responded by saying, "Both". They all believed that the app serves as a teaching-assistant application that helps children in learning and improving their mathematical skills while entertaining them at the same time.

v. The fifth question from the interview was: "Do you think that the device's size is suited for the PreMath Operations application?" All the teachers responded by saying that using a Samsung-sized device was favourable

because its screen size is just right for the PreMath Operations application.

vi. The interviews conducted with the teachers revealed their excitement about the PreMath Operations application, especially its design. They suggested that in order to make it more interesting, the colours should be improved. It was also perceived that the app could be made more interesting if an animated picture was incorporated. Moreover, the app helped the children in understanding and solving the mathematical operations. Given all the positive feedback, the teachers were hopeful that the PreMath Operations application can be utilised by the children in schools and at home with their parents.

vii. The interview results revealed the effectiveness of the PreMath Operations application in teaching subjects and reducing the burden of teaching and production for teachers and parents. It was revealed that it can even improve the children's learning motivation and their ability to identify mathematical skills. Moreover, it was discovered that a more enjoyable learning environment is fostered when mobile technology is integrated into traditional teaching.

5.3.2 Results of Children's Observation

One of the aims of this study is to evaluate the usability by looking into effectiveness, efficiency, and satisfaction of the PreMath Operations mobile game. A usability test is defined by the International Organisation for Standardisation (ISO)

(1998) as the degree to which certain users can use a product to achieve specific goals with effectiveness, efficiency, and satisfaction given a specific context. Therefore in this study, the ISO standard is adopted for usability measure and its definition. There are three important components for this definition:

1. Effectiveness: The accuracy and completeness of the method by which customers reach specific goals.

2. Efficiency: The accuracy and completeness of a goal in relation to the resources.

3. Satisfaction: The condition of being free from discomfort and having positive attitudes towards system use.

Based on this definition of usability, it is apparent that efficiency and effectiveness are components that possess objective characteristics. Satisfaction, on the other hand, is more subjective. Thus, with the help of a usability measurement introduced by Nielsen (2001), the metrics for effectiveness and efficiency can be measured. Measurement of satisfaction was done using the post questionnaire given to the children. Therefore, for this study the evaluation is adopted from (Ismail, Diah, Ahmad,, Kamal, & Dahari, 2011).

1. The Results of Effectiveness: Effectiveness measures the user's ability to complete a task presented in an application (Rubin, & Chisnell, 2008). This study measured effectiveness at each interface, with each interface representing the game levels. Every task that needed to be completed was listed down. If a task is completed successfully, it is marked with a 'Yes'. Every success mark is given a full credit of 100%. Tasks that were not completed successfully were given a 'No' mark. 'No' marks are given 0% credit.

A task is considered unsuccessful if, for example, the child does not complete the task in time, gives up, or incorrectly completes the task, among others. The 'Partial' mark represents a partial credit and corresponds to a 50% credit. It is up to the researcher's discretion if partial credit should be given. Table 5.1 the tasks that were evaluated for effectiveness. The evaluation elements presented in table 5.1 are adopted from Ismail, Diah, Ahmad,, Kamal, and Dahari (2011).To make analysis easier, the data collected were summarised and evaluated for its effectiveness using the success rate evaluation.

Table 5.1: List of Tasks for the Effectiveness Evaluation

Screen / Evaluation Element	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6
The game is challenging	Yes	Yes	Yes	Yes	Yes	Yes
The student do not find trouble in playing mode	Yes	Yes	Yes	Yes	Yes	Yes
The game attracted the student focus	Yes	Yes	Partial	Yes	Yes	Yes
The student answer each question and complete the levels of the game from first try	Yes	Partial	Yes	No	Yes	Yes
The students know what they seek in this game.	Yes	Partial	Yes	Partial	Yes	Yes
The tasks or stages have clear goals.	Yes	Yes	Yes	Yes	Yes	Yes
The interaction with the device is fun.	Yes	Yes	Yes	Yes	Yes	Yes
The game content is plentiful and interesting.	Yes	Yes	Yes	Yes	Yes	Yes
The student like to get more resources in this game	Yes	Yes	Yes	Yes	No	No

The student prefer to play the game in his/her house	Yes	Partial	Yes	Yes	Yes	Yes
The game was very easy	Yes	Yes	Yes	Yes	Yes	Yes
The student succeed in answering the questions	Yes	Yes	Yes	Yes	Yes	Yes
Stage of game are match with students level	Yes	Yes	Yes	Yes	Yes	Yes
The student can know if the answers is correct or not	Yes	Yes	Yes	No	Yes	Yes
The scenes in this game fit its environment.	Yes	Yes	Yes	Yes	Yes	Yes
Size of screen and game picture was good enough	Yes	Yes	Yes	Yes	Yes	Yes
The operational processes are easy and intuitional	Yes	Yes	Yes	Yes	Yes	Yes
The students can guess the answers	Yes	No	Yes	Yes	Yes	Yes
The student can select the suitable levels	Yes	Yes	Yes	Yes	Partial	Partial
There is no needing to help and guide from the researcher	Yes	Yes	Yes	Partial	Yes	Yes

From Table 5.1, we can summarize all results into a simpler efficiency analysis table as in Table 5.2 below.

Table 5.2 Summary of Effectiveness Analysis Table

Answer	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Total
Yes	20	17	19	16	18	18	107
Partial	0	3	1	2	1	1	8
No	0	1	0	2	1	1	5
Total							120

In Table 5.1, 5.2 tasks are shown and each task has 6 attempts, giving a total of 120 task attempts. Out of this number, there were 107 successful attempts and 8 partially successful ones. There are total of 5 unsuccessful tasks will be ignored and placed as part of 5 × 0% = 0. The equation (Ismail, Diah, Ahmad, Kamal, & Dahari, 2011) shown below was used to compute the overall effectiveness rating for this set of tasks:

$$\text{Effectiveness (\%)} = (\text{Yes} + (\text{Partial} \times 0.5)) / \text{Total} \times 100\%$$

$$= (107 + (8 \times 0.5)) /120 \times 100\%$$

$$= 92.50\%$$

Using the equation above, the usability testing for the children revealed that the PreMath operations effectiveness is 92.50%. The effectiveness result of 92.50% proved that the prototype is completeness and usable for achieving specified math children skills goals. It can be said that effectiveness percentage 92.50 % (which is consider a high result) means the app is an easy tool which can aid children to learn the math material. The table 5.3 will explain what we observed for children playing mode. See the description table 5.3.

Table 5.3: Effectiveness description

Evaluation Element	Description	Factors
The game is challenging	The child plays in the game with focusing and insisting on completing the game at the end. This provide challenge factors	Challenge
The game attracted the student's focus	The child plays with full focusing and does not care what happen around him / her	
The student like to get more resources in this game	The teachers ask the children if they want more game like this	
The game content is plentiful and interesting.	The game contains questions according to the syllabus and the children are able to answer	
The student succeed in answering the questions	The children answer the questions without any confused in choosing the right answers	
The student can know if the answers is correct or not	When the children choose the wrong answer they can know because they try again to re-answer question	
The students can guess the answers	The children can answer the questions fastest than others	Mystery
The student prefer to play the game in his/her house	The teachers ask the children if they want to take this game to their house. so to explorer the game	
Stage of game are match with students level	All children solve the mathematics operations in the game one stage at a time and next level will be displayed when only they complete the level.	
The student do not find trouble in playing mode	The child was playing in the game with no external helping	Interaction
The student answer each question and complete the levels of the game from first try	When the child enter the game and start playing (answer the questions) he/ she choose right answers from first try	
The students know what they seek in this game.	After starting the game the children do not need any instructions they know what must do after completing answer each questions	
The interaction with the device is fun.	All children like the interactive button touch in the game	

The tasks or stages have clear goals.	In this we notice the student know what operations that he or she want to solve it	Freedom
The student can select the suitable levels	The children choose the level that suitable to their age	
The operational processes are easy and intuitional	The children touch the crocodiles and the fruits immediately to see and answer the questions	
The game was very easy	There is no difficult in answering or in complete the stages	Sensation
The scenes in this game fit its environment.	The children found the game was like a cartoon	
Size of screen and game picture was good enough	The children said they like the trees and the crocodiles and fruits	
There is no needing to help and guide from the researcher	The game was very easy to the children. For that the researcher does not give any comment to help them.	

2. The Results of Efficiency:

Efficiency measures how smooth the task is completed. Efficiency measurement uses a method and algorithm similar to the one used for measuring effectiveness. In Tables 5.4, 5.5 tasks are shown and each task that is completed smoothly is marked with a ‘Yes’. Again, a full 100% credit is given to every success mark. Tasks that are not completed smoothly is given a 'No’ mark. ‘No’ marks are given 0% credits. Some examples of unsuccessful tasks are the child requiring assistance from the researcher or child not being able to do the task completely during the first attempt (Ismail, Diah, Ahmad, Kamal, & Dahari, 2011; Diah, Ismail, Ahmad, & Dahari, 2010).

Table 5.4: Analysis of the Efficiency Using Success Rate Evaluation

Screen / Evaluation Element	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6
The student selected the correct menu to start the stages of game	Yes	Yes	Yes	Yes	Yes	Yes
The student can easily fix errors or mistakes that happened	Yes	No	Yes	Yes	Yes	Yes
The student do not find trouble to complete the stage and go to another	Yes	Yes	Yes	Yes	Partial	Partial
The student do not have trouble to find the start menu	Yes	Yes	Yes	Yes	Yes	Yes
Error and mistake done by the student was minimal	Yes	Yes	Yes	No	Yes	Yes
The student knows how to recover from errors and mistakes	Yes	Yes	Yes	Partial	Yes	Yes
The student succeed in choosing the correct answer	Yes	Yes	Yes	Yes	Yes	Yes
Level of interaction between researcher and the student was minimal	Yes	Yes	Yes	Yes	Yes	Yes
The child completed the game in the first try	Yes	Yes	No	Yes	Yes	Yes
The child knows whether their answer is correct or No	Yes	Yes	Partial	Yes	Yes	Yes
The child knows what to do during the game play	Yes	Partial	Yes	Yes	Yes	Yes

From Table 5.4, we can summarize all results into a simpler efficiency analysis table as in Table 5.5 below.

Table 5.5: Summary of Efficiency Analysis Table

Answer	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Total
Yes	11	9	9	10	10	10	59
Partial	0	1	1	1	1	1	5
No	0	1	1	0	0	0	2
Total							66

It can be seen on from table 5.5 that there are 2 tasks and each task has 6 attempts, for a total of 66 task attempts. Of the 66 attempts, 59 were successful and there were 5 partially successful tasks. Two unsuccessful tasks were ignored and signified by 20% = 0. The equation (Ismail, Diah, Ahmad, Kamal, & Dahari,2011) below was used to determine the overall efficiency rating for this set of tasks:

$$\text{Efficiency (\%)} = (\text{Yes} + (\text{Partial} \times 0.5)) / \text{Total} \times 100\%$$

$$= (59 + (5 \times 0.5)) / 66 \times 100\%$$

$$= 93.18\%$$

Using the above equation, the usability testing with children has led to the computation of a 93.18% efficiency rating for the PreMath Operations educational game. The efficiency result of 93.18% proved that the prototype accuracy in relation to the resources of the guidelines for achieving specified math skills children goals. It can be said that efficiency percentage 93.18 % (which is consider a high result) means the PreMath operations provide entertainment elements or we can said it build a bridge between the education game and traditional game. The table 5.6 will explain what we observed for children playing mode. See the description table 5.6.

Table 5.6: Efficiency description

Evaluation Element	Description
The student selected the correct menu to start the stages of game	Children choose the right level form the first try
The student can easily fix errors or mistakes that happened	When the children choose wrong answer the immediately know and change to the right
The student do not find trouble to complete the stage and go to another	The children finish the game easily
The student do not have trouble to find the start menu	The children know how to start and achieve the game
Error and mistake done by the student was minimal	There is no errors just when the student choose the wrong answer
The student knows how to recover from errors and mistakes	The children know to re-answer or re-choose the suitable level
The student succeed in choosing the correct answer	Most children choose the right answers
Level of interaction between researcher and the student was minimal	The researcher did not give any instruction
The child completed the game in the first try	Children complete the game with no mistake
The child knows whether their answer is correct or No	The game give the children "wrong" message when they choose wrong answer and "well done" for right answer
The child knows what to do during the game play	The children do not need any help to choose the stage or the level and know what they must do

3. The Results of Satisfaction: The questionnaires were used to measure the children's satisfaction ratings. After completing all the test scenarios, the children were made to answer these questions. The 5-point Likert scale was utilised to improve the structure of the questions and the corresponding answers (Ismail, Diah,

Ahmad, Kamal, and Dahari, 2011). The Likert scale ranging from 1 to 5 is shown on Table 5.7.

Table 5.7: Likert Scale Points Table Used in Questionnaire

Answer Options	**Likert Scale**
Yes, very much	5 points
Yes	4 points
Moderate	3 points
Not really	2 points
Not at all	1 points

The questions were adopted from Ismail, Diah, Ahmad, Kamal, and Dahari, (2011). They were designed in order to determine how the children felt about the game, how they liked it, and how easy it was for them. Table 5.8 shows the questionnaire and the children's answers, all presented in Likert scale points.

Table 5.8: Likert Scale Points Table Used in Questionnaire with Children

Test Questionnaire	Student 1	Student 2	Student 3	Student 4	Student 5	Student 6	Subtotal
The game was Fun and easy to play	5	5	5	5	5	5	30
The colors and layout of the interface attracts my attention	5	5	5	4	5	5	29
I'd like to complete the game's goals and achievements.	5	4	5	5	5	5	29
I do not find trouble to navigate between pages	5	5	5	5	3	3	26
I can complete the tasks and finish stages.	5	5	4	5	5	5	29
The game has some surprises	5	5	3	5	5	5	28

I would like to play this game at home	5	5	5	5	4	4	28
TOTAL							199

The 5 point Likert scale had a negative weighting represented by 1 and a positive weighting represented by 5. Each question answered by the 6 children had a possible positive response factor of 8 points. Since there were 7 questions, a total of 210 points represented 100% satisfaction. The net equation was used to calculate the satisfaction rating for the overall game:

$$\text{Satisfaction (\%)} = \text{Answer Point} / \text{Total Point} \times 100\%$$

$$= 199 / 210 \times 100\%$$

$$= 94.76\%$$

Using the above equation, the usability testing with the children revealed that the satisfaction rating for the PreMath Operations educational game was at approximately 94.76%. The satisfaction result of 94.76% proved that the children like the prototype and are satisfied with it. In table 5.9 describe what the children answer when they asked.

Table 5.9 : Satisfaction description

Evaluation Element	Description the questions that asked to the children
The game was Fun and easy to play	The teachers ask children are you enjoy when you are playing
The colors and layout of the interface attracts my attention	The teachers ask is the game take your full attention
I'd like to complete the game's goals and achievements.	Do you want complete the game at the end

I do not find trouble to navigate between pages	Do you have any trouble in select the levels or stages
I can complete the tasks and finish stages.	Can you complete all stages without any trouble
The game has some surprises	Do you find the game very exciting
I would like to play this game at home	Do want to take this game to your house

4. The Results of Single Metric for Usability:

To measure the application's overall usability (efficiency, effectiveness, and satisfaction), each usability component was expressed as a percentage. The usability of a product was calculated by averaging these three scores. The value of the overall usability can range from 1–100. Table 5.1 presents the summary of the effectiveness evaluation. The computation for the effectiveness rating is shown in Table 5.2. The calculations revealed that the rating is 92.50%. This value serves as a proof that challenging children were able to use the PreMath Operations effectively too. A summary of the efficiency measurement can be seen in Table 5.3.

The overall rating for efficiency is 93.18% and this proves that the PreMath Operations was used efficiently by the challenging children. The calculation for the satisfaction rating is presented on Table 5.6. of the app garnered a score of 94.76%. This value reveals that children were satisfied with their use of the PreMath Operations. The usability rating was calculated by calculating the average of the three measurement scores:

$$\text{Usability (\%)} = (\text{Effectiveness} + \text{Efficiency} + \text{Satisfaction})/3 \times 100\%$$

$$= (92.50 + 93.18 + 94.75) / 3 \times 100\%$$

$$= 93.47$$

The average of the three measurement scores was used to calculate the usability rating. Based on the equation above, the usability testing with children revealed that the PreMath Operations educational game had an approximate usability level of 93.47%. This value was obtained by averaging the 92.50% effectiveness value, 93.18% efficiency value, and 94.75% satisfaction value.

5.4 Summary

This chapter offers an outline and review of the application from the perspective of the user. The aspects pertaining to the performance and practicability checks were systematically defined, including those pertaining to the processes and results. The processes are individual and the results are consistent. The usability result of 93.47% indicated that the tool is usable for stimulating children. The practicability ranking is gauged on the basis of the average value of efficacy, effectiveness, and satisfaction. Given the effectiveness value of PreMath Operations is 92.50%, it can be said that the app is an easy tool which can aid kids in attaining their objective.

Likewise, the efficiency value of 93.18% suggests that the tool can be utilised easily for conducting the assignments. Moreover, the satisfaction value of 94.76% indicates that kids have agreed to the tool and are extremely happy with it. Thus, the users stated that the application was useful and suitable, considering the results shown in this chapter. The next chapter will offer a review of the conclusion drawn from this assessment and provide suggestions for further analysis.

CHAPTER SIX

CONCLUSION

6.1 Introduction

This chapter provides the conclusion of this research. It includes revisiting the objectives that have been achieved and presenting its future works and limitation together with some recommendations. In this dissertation, Chapter One presents the overall research ideas followed by Chapter Two, where related literatures are being discussed. Chapter Three outlines the complete methodology of design and evaluation, beginning with the identification of the problem to the evaluation of the results. Furthermore, in Chapter Four, we have explained the concepts of the PreMath Operations, which is a prototype for the proposed design strategy for mathematic educational game which is based on effective factors by Shi and Shih (2015). Then, Chapter Five reviews the results and the investigations of the study.

6.2 The Achieved Objectives

This section outlines the achieved objectives that have been set out in Chapter One.

Objective 1: To identify various educational game factors for designing educational game for children.

For understanding the designs of the factors involved in designing an informative game app, some simple and generalized usable models have to be reviewed and followed. Such a model acts as fundamental for designing the usable game, which helps in teaching the children and improving their skills. In this study, the model of Shi and Shih (2015) has been chosen because they found 11 crucial game-design factors that assist educational game designers in developing interesting games. Also it focuses on making educational game design more fun.

Objective 2: To design a mathematical educational game based on the identified game factors.

We defined the app structure of the PreMath Operations depending on the fundamental resultant designs and requisites gathered in Chapter Three. The PreMath Operations is seen to be an interactive application which could potentially help the children to improve their mathematical skills, which is achieved by the demonstrations of the learning of these skills as the progressive assignments for deriving the correct mathematical solution. After interviewing with teachers and based on the Shi and Shih model (2015), we first construct the design strategy as presented in Chapter 4, which is followed by the low fidelity prototype and high fidelity prototype and testing, which was further explained in Chapter Four.

Objective 3: To evaluate the usability of the proposed educational game design by measuring effectiveness, efficiency and satisfaction.

We used the PreMath Operations app and assessed the app for its usability by looking at effectiveness, efficiency, and satisfaction. The PreMath Operations designed based on Shi and Shih (2015) model (9 usable factors) and teachers' interview. Moreover, we include the syllabus by ministry of education Malaysia for standards 1, 2 and 3 of primary school children.

The usability measure is adopted from ISO (1998). We have mentioned all the specifications regarding the evaluation in Chapter Five. The usability result of 93.47% indicated that the tool is usable for stimulating children. The practicability ranking is gauged on the basis of the average value of efficacy, effectiveness, and satisfaction. Given the effectiveness value of PreMath

Operations is 92.50%, it can be said that the app is an easy tool which can aid children in attaining their objective. Likewise, the efficiency value of 93.18% suggests that the tool can be utilised easily for conducting the assignments. Moreover, the satisfaction value of 94.76% indicates that kids have agreed to the tool and are extremely happy with it. The results of effectiveness ‘, efficiency show that all the users have found the app very practical and convenient to use. Also, we observed the model parameters to determine that they functioned properly.

6.3 Limitations and Recommendations for Future Studies

Throughout this study, we have observed several limitations as listed below:

6.3.1 Time Constraints

In our study, the prototype contained two different levels containing small pictures and basic animations. However, some levels in the prototype, like video and sounds, were not developed. A limited amount of time contributed to these issue. Nevertheless, the design and the prototype has shown some potential to be applied in mathematic teaching and learning session.

6.3.2 The narrative and sociality factors

The narrative and sociality factors did not include in PreMath Operations app because the students will need the explanations form their teachers or parents and the goal of game to provide learning with no external help and the students are too young to understand the story telling in the game. Moreover, the sociality factor can involve a simple interface for communication or for players to battle with each other that

would make it more interesting but it is the teachers' concerned that it would be more of a distraction for young learners that they would minimize their learning.

6.3.3 Future work

Any game-based learning coursework for the primary school children, level 1, which helps them develop their learning abilities, consists of the below-mentioned features, which can be used by the researchers in the future:

1. The researcher must include a lot of sample information along with several examples for a better result. For this study, we obtained examples from the Sekolah Kebangsaan Mergong, Alor Setar, Kedah, Malaysia. The teacher's opinions were used as the feedback. However, in the case of future research, the investigator must take into consideration the examples from many other places like the rural areas and also gather proper requisite information from various other tools and the teachers. Furthermore, the researcher also needs to improve the software model for the app by using different settings.
2. This application is limited to the children. Hence, several more improvements must be carried out to include more people from differing age groups.
3. This study has been restricted to Malay and English languages; however, one can similarly modify it for any other language.
4. This study permits the guardians to distribute all material using a Wi-Fi connection on their mobiles.

6.4 Contribution of Research

This study contributes towards providing a suitable, specific design strategy for mathematic educational game with the intention that the learning and the teaching of mathematics to children can be more fun and interesting with the help of modern

technology. This has been achieved by designing and implementing the use of practical and convenient easy-to- use Edutainment game app. We have proposed the specific design strategy pertaining to mathematics that has been proven its usability and this design is suitable for the children and could potentially help them develop their mathematical skills. This study has considered the benefits of the app that has been summarised as below:

1. The participants using the technological devices are very interested in the learning of these technologies as they combine game playing with the development of learning abilities.
2. The teachers who are seen to depend on the technological device show more interest in the learning, as the technology is seen to be very flexible and easy due to its vast Audio-Visual effects.

6.5 Summary

In this study, we have designed a specific design strategy for mathematic educational game (edutainment app) for children and investigated the outcomes of our edutainment app, and the results indicate that our design translated into the app has a positive influence on helping the children develop their skills. The study has gathered inputs from various points for creating a substantial influence on the data used based on the proposed design. For future work, the researchers can use this design strategy and develop it further to include a larger age group of people. This study helps the general people, as the developed design strategy offers the teachers and the parents with a special facility and helps them educate and teach the children in a proper manner. Finally, this app would potentially help the children develop better mathematical skills through game play. With that, we have been able to achieve the defined objectives of the study.

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Appendixes I- Interview questions with the teachers

Interview questions
What are the main problems faced by the children in learning math?
What are the educational approaches to teaching kids?
Is the traditional education currently used to achieve the goals of education and improve their skills?
What do you think about educational video games?
What kind of technological devices that children preferred and using it?
Do the kids spend the most time with mobile devices?
Do the kids spend the most time with electronic games?
Which game do you think your students would like better and why do you think so?
Would you use game in your class? Why or why not?
What do you think would be the best way to use game for teaching in a class?
Do you currently use (mobile app) in mathematics education for children?
If you use the mobile app what character that children preferred?
What are the main problems in the current games that you think?
Do you think that mobile educational applications will improve the children mathematical skills?