Trilingual Mathematics M-Learning for Kindergarten Students

By

Khor Seng Hoong

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Technology (Hons)
(Business Information System)

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CERTIFICATION OF APPROVAL

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Approved by,

_____
(Assoc. Prof. Dr. Wan Fatimah Wan Ahmad)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
SEPTEMBER 2012

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

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KHOR SENG HOONG

ABSTRACT

Mobile-learning (m-learning) has been the current trend in this mobile age and education in technology has been a norm to students. This project aim to investigate the right method of learning mathematics effectively that leads to the development of an appropriate m-learning application for pre-school students of age four to six. Children of age four to six have difficulties learning the basic concepts of mathematics as they are yet to be able to perform mental operations. They have short attention span and some parents are too occupied to accompany their children nowadays. Furthermore, there is limited local material in the market. Hence the main objectives of this project are to develop a trilingual mathematic m-learning application for pre-school students that help boost learning innitiatives at the same time able to improve their memory capability and to perform user testing on the m-learning application developed. The mathematical concepts that are included in this application are count, addition and subtraction. The development approach for this project is the Rapid Application Development (RAD) model as it has rapid prototyping features and could be developed iteratively according to users' needs and expectation. Eclipse Indigo is the main development platform for this m-learning application. Based on the user testing, this application has gained full recognition from targeted users and all of them learned something from this application.

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ABBREVIATIONS AND NOMENCLATURES

M-Learning	Mobile Learning
MIT	Massachusetts Institute of Technology
NCTM	National Council for the Teachers of Mathematics
SDK	Software Development Kit
RAD	Rapid Application Development

CHAPTER 1
INTRODUCTION

1.1 Background Study

Technology have been widely used in the education industry especially in this mobile age, therefore it is not something new to the public. Using technology in education has been a great help in anticipating student's participation in learning. It is a platform to practice the syllabus they learnt in schools for better memory enhancement and application of knowledge acquired. Technology in education has been widely implemented especially in mathematics. An excerpt obtained from the National Council for the Teachers of Mathematics on the role of technology in the teaching and learning of mathematics is as follow:

Technology is an essential tool for learning mathematics in the 21st century, and all schools must ensure that all their students have access to technology. Effective teachers maximize the potential of technology to develop students' understanding, stimulate their interest, and increase their proficiency in mathematics. When technology is used strategically, it can provide access to mathematics for all students (NCTM, 2008).

In this mobile age, more than half of the world's population now owns a cellphone and children under 12 is the fastest growing segments of mobile technology users in the U.S. (Schuler, 2009). Mobile learning (m-learning) is the implementation of technology in education on the move where learning takes place in different location, time or context. M-learning helps accessing of knowledge more efficient and effective to an individual as they could easily seek knowledge with the existence of a mobile device. This mobile device could be a smartphone, PDAs, iPods, iPads, tablets or any other educational portable device.

Mathematics should be taught to children since young to instill their interest in it and to shape the basic foundation of mathematics. Children of age four to six have different learning approaches as compared to primary or secondary school students. While going through this stage, children could not perform mental operations very well as they prefer experimenting with the new knowledge gained and form their own hypothesis out of it. Hence, to approach children in this stage, a right method has to be considered to make learning easier and more engaging for them. Thus, the research on this project is to develop a suitable learning platform for these children to acquire knowledge at their optimum ability. The proposed learning platform in learning mathematics effectively for kindergarten students is m-learning using multisensory approach.

Developing on Android platform is chosen due to the open-source nature of the software platform and software development kit plus the high number of users in the market. According to a statistic obtained from Forbes, the percentage of android market share outnumbered any other mobile operating system market share, where 64.1% mobile devices are sold under Google's Android, 18.8% mobile devices under Apple and the remaining 17.1% falls under other mobile devices operating system. Android applications have a huge target market and it is easily accessible from the Google Play market. Thus, choosing the right platform and operating system to develop the application is vital in introducing a new application to the market. Figure 1.1 shows the statistics of each mobile operating system market share in the second quarter of year 2012.

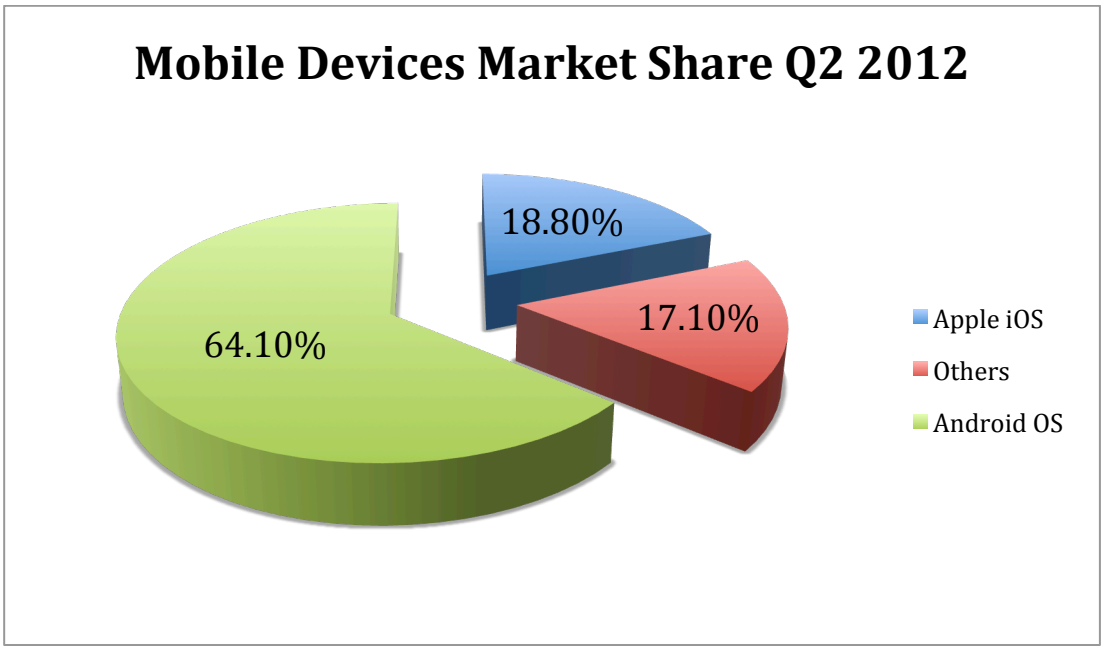

Figure 1.1 Mobile Devices Market Share Q2 2012
Source: http://www.forbes.com/sites/darcytravlos/2012/08/22/five-reasons-why-google-android-versus-apple-ios-market-share-numbers-dont-matter/

Based on the statistics above, developing the m-learning application on android platform would be most suitable to target the larger market. Through m-learning, children could access the application anywhere and at anytime. The interactivity and animative feature on the m-learning could trigger the excitement and eagerness of students in learning mathematics. Therefore, this projects aims to develop a trilingual mathematics mobile application named 'M-Math Story' which focuses on the multisensory techniques, targetting users of age four to six using Eclipse Indigo as the application development platform.

Currently there are many existing m-learning applications on mathematics in i-Tunes (Apple store) and Android market. All these are proofs that m-learning is the current trend and many kids are now increasingly being exposed to smart mobile devices be it their parent's or siblings' mobile devices. This also means that children get to access to this mobile applications more easily and frequently at home.

1.2 Problem Statement

1.2.1 Problem Identification

Not every child has the same level of mental readiness although they are of the same chronological age (Van de Walle, 2007; Kamii and Rummelsburg, 2008). Some children has faster brain development whereas some may pick up new things slightly later than the rest. According to Piaget (1965), not all students may be capable of acquiring the mathematical concepts at the same time as others. As a result of this different level of mental maturity in children, kindergarten teachers are having difficulties in introducing mathematical concepts merely by classroom presentations. Students at various developmental level and differing learning capabilities can be left behind while the teacher continues on the next lesson (Rains, Kelly and Durham, 2008).

Pre-school students are having difficulties grasping the basic concepts of mathematics due to the current stage they are in where they are yet to be ready for mental operations. At this stage, children tend to use more of trial and error method where they experiment with their own hypothesis and come up with new ideas. Hence they would need a different approach to learn mathematics instead of just classroom education.

There is lack of local material for children in the market. The current applications in Google Play and iTunes market does not cater to the malaysian context. There are no single application for children that is in three languages; malay, chinese and english for children of malaysia.

Students of age four to six have a very short attention span. They tend to fidget around and could not focus for long period while learning in a closed-up area. They need something more interactive, engaging and fun to promote learning and something which is mobile rather than having to stay still in a classroom setting.

Nowadays, parents are too occupied to spend time with their children. Hence letting children explore with their smartphones is a common way to keep them occupied while they are handling their busy lifestyle. Not just any applications are suitable for these children. The right application will help them learn at the same time keep them occupied for longer period of time while parents are busying.

1.2.2 Significant of the Project

This project discovers the right methods of learning mathematics effectively and indulge children's interest in mathematics at an early stage. Learning mathematics effectively can be further enhanced by using multi-sensory techniques in the learning process. This could be a mixture of visual, auditory, touch and kinesthetic-tactile sensory that could help stimulate the mind of children and capture their attention. M-Math Story is a trial and error type of m-learning application that focuses on linguistic, logical and mathematical, musical, visual-spatial and kinesthetic (touch) senses. M-Math Story also provides scenario-based situation for children to visualize the real situation that may occur in life.

The m-learning application here means that this M-Math Story could be accessed anywhere and at anytime. Children will have the mobility freedom advantages as most children prefer to move around rather than staying still at one spot. This encourages them to access the application even more often and cultivate learning innitiatives.

Most importantly is the functionality that is available in this application where children will be exposed to video tutorial of the mathematical concepts followed by some exercises for users to practice and enhance their level of understanding. The video tutorial teaches children step by step on how to solve a particular mathematic problem and the use of visual and auditory aid enhances memory

capability. The exercises enable children to use the trial and error method to understand the concepts of the subject and visualize the real situation.

Besides, this application caters to the three main languages mostly spoken by Malaysians, which are the Malay, English and Chinese language. This is to ensure that students get to learn comfortably in their mother tongue language. Moreover, they can even learn more than one language instead of just grasping the concepts of mathematics.

1.3 Objectives

The objectives that this project focuses on are as follow:

- To research on the best method for children to learn mathematics.
- To develop a trilingual mathematics m-learning application for pre-school students that helps boost learning innitiatives as well as improving their memory capability.
- To perform user testing on the m-learning application developed.

1.4 Scope of study

The scope of study in this research project is divided into few categories.

Target Group:

- The target group are pre-school students of age four to six years old.
- Target location of user testing would be the housing area around Setapak, Kuala Lumpur.

Focus topic:

- Discovering the theory that best suits children's learning capabilities on mathematics.

- Design and develop a trilingual mathematic m-learning application which covers mathematical operation of count, addition and subtraction.

Approach:

- Multisensory technique approach which involves linguistic, visual, auditory and kinesthetic (touch) senses.
- Mobile learning application using trial and error method.

1.5 Relevancy of Project

The trilingual mathematics mobile learning application will help pre-school students master mathematics concepts more effectively outside of class and develop their interest in learning mathematics. This project discovers the best method for children to learn and engage themselves with mathematics to familiarize themselves with the numeracy and operations.

1.6 Feasibility of Project

1.6.1 Technical Feasibility

The main machine that is used to develop this application is a 13 inch MacBook Pro laptop. MIT App Inventor was the platform for developing the prototype of the application. This includes the user interface, basic functionality and rough flow of the interface. The main platform that is used to develop this m-learning application is the Eclipse Indigo on Android Platform. The main programming languages that are used to develop the application are Java and XML. An 8.9 inch tablet is used as the testing device for this application. Pencil v0.4.4b is used for the creation of animation and iMovie as the video editor for the video tutorial. GIMP 2.8 is the main graphic creation and editor for this project. A four by five inch graphic tablet is used as the drawing tool for the graphics.

Android has gained recognition over the past few years and it is now powered by Google Inc. Developing an application under Android is definitely a safe way to enter the mobile-learning application industry. Furthermore, applications on Android are highly accessible by all android supported smartphones which caters for about 64.1% of the mobile devices market share.

1.6.2 Schedule Feasibility

The time given for the completion of this project is 28 weeks (2 semesters) whereby it is divided into two phases. The first phase is carried out in the first semester which includes the research and findings on the proposed title as well as learning period for the application development software. The second phase falls under the second semester where the development of application, prototype, user testing and implementation of the project takes place. The full prototype is expected to be done by 2nd December 2012 which is by the 26th week.

1.6.3 Economic Feasibility

Eclipse Indigo and MIT App Inventor is an open source software for android platform development. There will be no cost incur there. Other supporting softwares such as Pencil 0.4.4b and GIMP 2.8 is a free software available for download in the internet. iMovie is a free application which comes with the MacBook Pro and as for the graphic tablet, it has to be purchased. The total cost of software is RM0 and the total cost for hardware is RM140. The tablet to be used for user testing is sponsored by the University. The application developed would be available free in the Google Play market.

1.6.4 Operational Feasibility

The application developed would undergo few usability testing by the preschool students in the targeted user location. Once users' needs and expectations are

met, the application would be launched into the Google Play market for Android users to download. The application has two version. The first version is just a trial version of the application, whereas the second version includes the full funtionality of the application.

The application has undergone three testings, one testing was conducted with the supervisor of this project, and the other two testings were conducted with the users of the application. Through the involvement of users in this project, the application is refined and rebuilt to meet up with the needs and demands of users.

CHAPTER 2
LITERATURE REVIEW

2.1 Children and Technology

Research shows that the use of technology in education enhances children's fine motor skills, alphabet recognition, concept learning, numerical recognition, counting skills and pre-mathematical knowledge, cognitive development, and self-esteem or self-concept (Li and Atkins, 2004). Subrahmanyam et al., (2000; 2001) believe that home computer use enhances children's visual intelligence skills, such as the ability to read and visualize images in 3-dimensional space and trace multiple images simultaneously.

As supported by Subrahmanyam et al., (2000; 2001) frequent practice of technology in home and community settings by young children may influence their early literacy no less than any other purposeful learning (New, 2001). Indirectly, children would be able to grasp the concepts of mathematics as well as literacy while having fun.

National Council for Teachers of Mathematics has several goals and one of the main goals is to create a vision for mathematical literacy in an increasingly technological world, which requires application of skills and knowledge across diverse disciplines (Yelland, 2001). This goal supports the need to have a mobile learning application for pre-school students that covers multi-sensory techniques on learning mathematics.

Based on a study done by Mayer, Schustack and Blanton (1999) on cognitive consequences of educational technology in children's learning, it is confirmed that children who use educational software in an informal, collaborative context learned content knowledge about computer literacy, became more proficient in focusing on

main aspect of instructions, developed planning strategies for learning new games and also improves in basic academic skills. They also reported that these students outperformed their peers who did not participate by having greater levels of improvement in their performance on basic reading and mathematics achievement standardized tests.

2.2 Mobile Learning and Education

Mobile learning (m-learning) is a type of learning acquired while on the move using the advancement of technology such as smartphones, tablets, iPod devices or portable gaming devices as a tool in making mobile learning a more interactive experience. Brown's (2005) perspective on m-learning is that it is an extension of e-learning with mobile devices such as cell phones, PDAs, and iPods as the main device for learning. The transition of e-learning to m-learning is a revolution as it includes the change in terminology and mindset in the process of designing and planning learning outcome and goals (Laouris & Laouri, 2008). The advantage of using the mobile technology in learning is that learning of the contents could be done dynamically dependent on the learner's location, context and device (Sharma & Kitchen, 2004).

Reapplication of knowledge that was gained earlier in classroom in a different context could help learner remember the knowledge for a lifetime (Sharples et al., 2009). Mobile learning has became more prominent in the lives of children around the globe and there has been an innitiative between the national ministries and local schools in experimenting the use of these devices in the teaching and learning industry (Shuler, 2009). This amplifies the need of change in classroom culture (Mathee & Liebenberg, 2007) Findings shows that some educators in Asia now contemplate that mobile learning is a productive approach in achieving the Education for All (EFA) goal of universalizing literacy by 2015 (Deriquito & Domingo, 2012). Countries like Bangladesh and Pakistan with high populations of illiterate citizens, are engaging mobile learning approach for basic education and literacy development (Deriquito & Domingo, 2012).

The key opportunities of mobile learning based on a research done by "The Joan Ganz Cooney Center" at Sesame workshop is as follow (Schuler, C., 2009):

1. Encourage "anywhere, anytime" learning

Mobile devices enable students the convenience to learn and practice the knowledge gained outside the classroom. Reapplication of knowledge is important in storing lifetime knowledge and applying it in a real-world context is encouraged, as it aids in making learning environments in school and at home more exciting and closely related.

2. Reach underserved children

Vast amount of mobile devices are available for lower cost in the market and there is much higher opportunity for lower income communities to own one now as compared to before. The higher accessibility of mobile technology can help bring forward digital equity, and enables children from economically disadvantaged communities and those from developing countries to have a chance in learning through a better and more inspiring manner.

3. Improve 21st-century social interactions

Mobile technologies are essential in the success of the 21st century as it have the power to nurture and stimulate collaboration and communication.

4. Fit with learning environments

Mobile devices are the common technologies in this mobile age era and can help outclass many of the challenges corresponding with more advanced technologies, as they fit easily within various learning environments.

5. Enable a personalized learning experience

Every child has different learning capabilities and instructions should be adaptable to individual and diverse learners. There are great opportunities for supporting differentiated, autonomous, and individualized learning through mobile devices.

2.3 Model / Theory best suit children's learning capabilities

The development of human brain progress through different stages of cognitive development. As a child develop through different stages, their abiity to assimilate diferent types of material differs from the stage before. Children will be ready for new knowledge and skills according to their own brain development. There are several stages of mental readiness in children. These stages are the sensorimotor, pre-operational, concrete operational and formal operational. Sensorimotor stage are usually infants from birth to approximately two years of age whereas pre-operational ranges from two to seven years old. Concrete operational and formal operational are from seven to eleven and twelve to thirteen years of age respectively. These are just rough approximation of time frame on which the children enter each stage as each individual have different developmental level however the order of these stages are universal (Piaget, 1965). The stage that will be focused in this paper is the pre-operational stage.

Children of pre-operational stage are from the age group of two to seven. In this phase of life, a child does not have the capability to perform the mental activities Piaget called "operations" (Piaget, 1965). One of these operations closely related to learning the mathematics concepts is the conservation of quantity where the quantity of something remains the same although there has been changes to the order of appearance (Rains et al., 2008). Children of this stage could not distinguish the similarity of the quantity of something after it has been repositioned. Furthermore, they would have an egocentric perspective of thinking as they tend to be more self-

centered and have difficulty accepting other views but their own (Thorne and Henley, 1997).

One good example of the conservation of quantity could be obtained from Rains et al., (2008) paper where they demonstrated an activity performed by a teacher and a child. Based on Figure 2.1, in situation A, the teacher and child arranged 8 sticks inline with one another and the child assumed that they have the same number of sticks. However, in situation B, when the child rearranged the sticks further apart from each other and has wider range of arrangement as compared to the teacher's arrangement of stick, the child assumed that he has more number of sticks. They cannot see the concept that the sticks can be brought back to its original state and hence having the same number as before (Bruner, 1973). Piagetian's Theory suggested that until a child reaches at least the beginning of the concrete operational stage development, they would not be able to grasp the abstract mathematical concepts. Concrete operational stage is a phase where a child is able to perform mental operations and develops the concept of conservation. Hence children in pre-operational stage would learn best in the trial and error method where they try out different possbilities several times with the help of language and mental images.

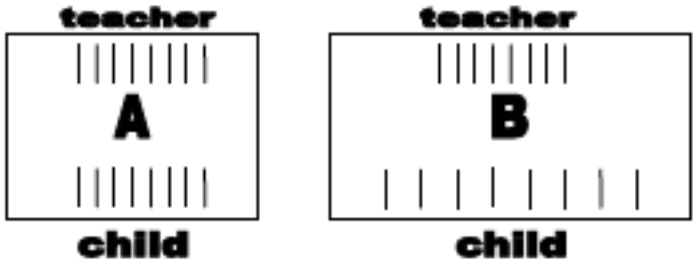

Figure 2.1 Demonstration of Conservation of Quantity Task (Rains et al., 2008)

There are several situation with pre-school students where elementary teachers has to take into consideration and the right teaching method has to be sorted out in order to maximise effectiveness of student's learning.

i) A child's stage in development may be the cause of their inability to understand abstract concepts which will then affect their progress in the class's mathematical curriculum.
ii) A child has their own hypothesis in learning new things and tends to construct new ideas based on their previous knowledge.
iii) The right teaching materials and appropriate methods has to be analysed before applying it on children.
iv) Different children may have different ways of learning.
v) Transition between stages may be different for each child.

Without correct teaching tools and methods, the child who needs extra attention in acquiring the knowledge may be left behind and the basic concepts of mathematics will never be understood (Rains, Kelly and Durham, 2008) resulting in slower learning progress as well as unattentiveness in learning. Thus, what they proposed in their paper is multi-sensory teaching techniques which involves more than one senses in the elementary teaching.

Children under three or four years were unable to form stable representations of events and thus, were unable to remember them. Hence an appropriate approach to help them remember new knowledge that they have learnt are through repetitive process via multi-sensory techniques. A combination of visual, auditory, kinesthetic (touch) and emotional may increase their attentiveness in learning. Children do not stay focus on one single activity if it is not captivative. They will tend to lose focus and skip learning that subject. Therefore, there is a need to look for alternative to the traditional teaching methods of mathematics. The use of technology in mathematics has shown an increase in mathematical achievement of children in pre-school and primary grades. (Clements et al., 1993)

Therefore the best model that promotes effective learning of mathematics could be obtained from Piaget theory where he emphasized on the trial and error methods of learning in the pre-operational stage as well as the multi-sensory teaching techniques

from Rain et al., (2008) followed by the use of technology in teaching from Clement et al., (1993) as supported by Li and Atkins in 2004.

2.4 Trilingual Education

Children are able to grasp the concepts and remember different languages words and pronunciation if they can learn different language with the same image, which enhance their connection with different language, thus improving their memory. Kim et al. (2008) points out that the emerging mobile technologies provide greater language learning solutions in an interactive, pervasive and convenient way. Children learn different languages even better on mobile applications. Hence if mobile learning is to be conducted in multiple languages, children will be able to learn the additional language and the mathematical concepts at the same time.

Code switching is often implemented in multiracial countries like Malaysia where Malaysians use it as a sociolinguistic tool as a means of communication aid rather than obstruction to communication (Lim, 2008). Code switching means moving from one language to another with the same speaker (David, 2003). There are many reasons to code switching. Based on a study to examine the ways code switching is employed by pre-school Malaysian children done by Karen Kow (2003), the author listed 9 conditions where code switching is favorable. The 9 conditions are as listed below:

i) Lack of one word in either language;
ii) Some activities have only been experienced in one of the languages;
iii) Some concepts are easier to express in one of the languages;
iv) A misunderstanding has to be clarified;
v) One wishes to create a certain communicative effect;
vi) One continues to speak the language latest used because of the trigger effect;
vii) One wants to make a point;
viii) One wishes to express group solidarity;

ix) One wishes to exclude the another person from the dialogue.

Pre-school children may not have a good grasp over language, hence different language options helps provide greater scope of explanation and wider opportunity for understanding.

2.5 Existing Mathematics M-Learning Application

There are many mobile-learning applications for pre-school students in Android market as well as Apple i-Tunes store. A few selected ones would be reviewed here in this paper. “My Math Flash Cards App” is one of the applications found in the i-Tunes store where it is developed by Pankaj Humad in 2010. The features in this application includes four basic operations of mathematics which are the addition, subtraction, multiplication and division. The function of the application is to randomly generate flash cards with questions for students to answer. The specialty is that users could customize which particular fact to focus on. For example if user pick number 2 to be the focus fact, then the maths operations on the number 2 would be emphasized on. It is purely static and does not have animation graphic which would be dull and uninteresting for children. Besides, it is less interactive as compared to other children application. Figure 2.2 shows a few screenshots of the application.

Figure 2.2 My Math Flash Cards App Screenshots

Other application from the i-Tunes store is an application called "Math is Fun: Age 4-5 (Free)". Joly (2012) claims that this application has 8 fun activities which teaches kids on how to recognize numbers, count, order numbers, play with weight, determine ranking and handle shapes. The main features of this application are simple and children-friendly game design plus high quality graphics and animations. This application does not include any video teaching or concepts of how this activities works. It is just pure questions without assessment. Figure 2.3 shows the sample screenshots of the application.

Figure 2.3 Math is fun: Age 4-5 (Free) Screenshots

Infinut (2012) developed a mathematic for kindergarten application in android platform named "Kindergarten Kids Math Lite" where it has 30 sets of exercises that teach mathematics to young kids. The function of the application includes learn counting, number recognition, sequences, addition and subtraction for numbers 1-20 in small fun exercises and the target age group is 4-7 years old. Stansberry (2011) claims that the interface doesn't have the fancy graphics that you see on many iPad apps, but this Android program offers a variety of exercises that speak to the way young minds pick up mathematical concepts. For example, by moving balls in and out of a box users are able to actually see the process of addition and subtraction. Figure 2.4 shows the screenshots of the application.

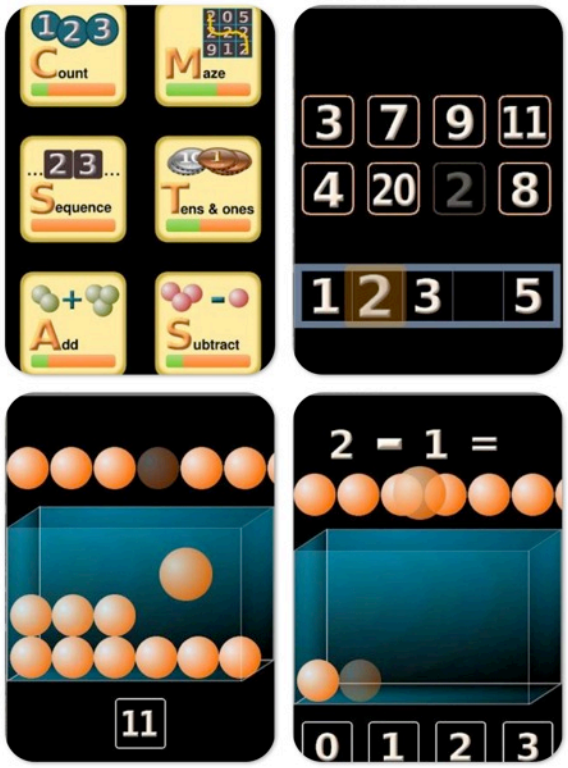

Figure 2.4 Kindergarten Kids Math Lite Screenshots

There are many more applications in the android market and i-Tunes store however non of them have video teaching on the mathematical concepts. There are no application with trilingual option as well. The common functions among those applications are exercises and picture representation of the mathematic concepts.

Based on the reviews gathered from users of the top 6 iPhone or iPad pre-school mathematics mobile application in the market, to sustain children's interest in the application, there has to be certain objectives that they have to achieve to keep them playing until the end. The rewards from solving the questions given should be satisfying and attractive enough to ensure that children will want to reaccess the application the next time they play.

Example of applications with rewards and objectives are like quest seeking and puzzle solving applications. Figure 4.5 shows an application “Park Math” reviewed from iTunes store that has appealing user interaction and high sustainability in children’s interest.

Figure 4.5 Park Math Application

To select the type of games, there are several icons children can choose. The activities in the application consists of:

1) Slide: Addition – Help the duck to climb up the slide and count as he goes.

2) Swing: Counting – Count the rabbit as it swings back and forth.

3) See-saw: Greater than/less than – Balance a seesaw by adding and subtracting mice.

4) Apple Tree: Subtraction – As the apples drop from the tree, learn how to subtract.

5) Bench: Sorting – Put the dogs in the correct size order. Put the numbers in sequence.

6) Sandbox: Patterns – Complete a pattern with the correct toy.

7) Picnic: Counting – Feed the hippo the correct amount of food items.

All these activities with objectives to be achieved help to sustain children's interest in playing the game and help them learn as they play.

Figure 4.6 is another example of an application that has goals to be achieved and rewards children with something interactive to engage in. The game named Math Bingo requires children to solve the mathematic question given and try to get a row of five little bugs. Once they achieved the goal, they will be rewarded with a Bingo Bug. The bugs collected could interact with children. To interact with the bugs, children just tilt the device or tap on them and they will produce cute little giggling noises.

Figure 4.6 Math Bingo Application

CHAPTER 3
METHODOLOGY

3.1 Research Methodology

The main research methodology that would be used in this project is the Rapid Application Development (RAD) model as shown in Figure 3.1. This methodology is chosen due to the rapid prototyping nature where development of the application could be done in the early stage and users' needs and expectations could be addressed at the development phase. This method is flexible and adaptable to changes reducing the overall project risk. RAD is an object-oriented approach to the m-learning application where development of each function could be done gradually using the software development tool which in this case is the MIT App Inventor. This tool is used to generate screens and exhibit the overall flow of the application in a prototype manner.

Furthermore, the time constraint has been another important contributor to the choice of RAD model. By using RAD method, application development speed could be enhanced and quick results or interface could be produced. Further update, improvisation and innovation could be done gradually according to users' feedbacks. The timeline for this project is very short which is 7 months and it amplifies the need to use this methodology. RAD helps reduce time spent on the detailed pre-planning of the project . The analysis and planning of the project could be done concurrent with the project development to speed up the whole process.

There are four main phases in RAD model which consists of:

- Analysis and Quick Design Phase
- Prototyping Cycles (Building, Refining, and Demonstrating process)
- Testing Phase
- Implementation Phase

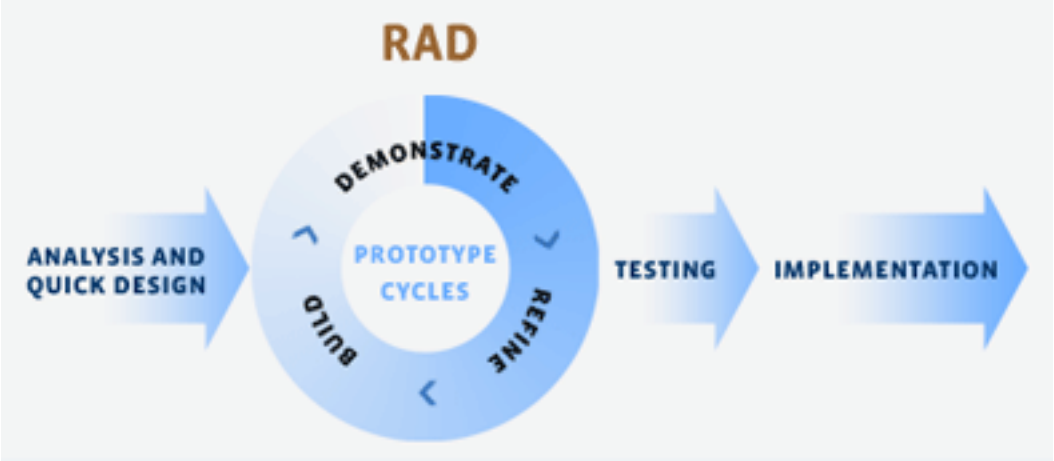

Figure 3.1 Rapid Application Development Model

The details of each phases is explained further in the next section.

3.2 Project Activities

This project undergo several phases as mentioned under the methodology section of the paper. Table 3.1 shows the detailed process of each phase.

Table 3.1 Phases in RAD model of the Project

Phase 1 – Analysis and Quick Design	The purpose of the project is defined and detailed research is carried out to gather the basic information required to develop the application. The gantt chart and key milestone is properly planned to keep the development of project on track. First draft of the interface of the application is designed using the MIT App Inventor to see the logic and functions that should be included.
Phase 2 – Prototyping Cycles	**Build** This stage is the innitial development of the prototype on the MIT App Inventor to have an animated view of the design. **Demonstrate** The prototype would be demonstrated to supervisor for feedbacks and ideas for improvements. It would also be demonstrated to a few selected children in the age range of 4-6 to get their response on the application. **Refine** Update and improve on the application based on feedbacks from users and supervisor to meet their needs and expectations. The first refinement is based on an informal testing done with the supervisor on the interface and functionality of the application developed using MIT App Inventor. The application is then rebuild using Eclipse Indigo where there are better memory capabilities and have more functions as compared to the MIT App Inventor. Second refinement is based on an informal testing done with targeted users and the design of the application has then been

	improved. Third refinement is done after a complete user testing with targeted users and after getting feedback from the supervisor. The quality of the audio, video and graphic design is improved.
Phase 3 – Testing	Once the application has been improved, enhanced and refined, usabilty test and user accpetance test was conducted with the children at the targeted user location. This is to ensure that the application is fully accepted by children and is user-friendly.
Phase 4 - Implementation	During this phase, a complete working application should be ready to be launched into the Google Play market for wider range of children to use and benefit from this m-learning application.

3.3 Gantt Chart and Key Milestone

Figure 3.2 shows the Gantt chart of this project for both first and second semester, specifying the process involved and the key milestone:

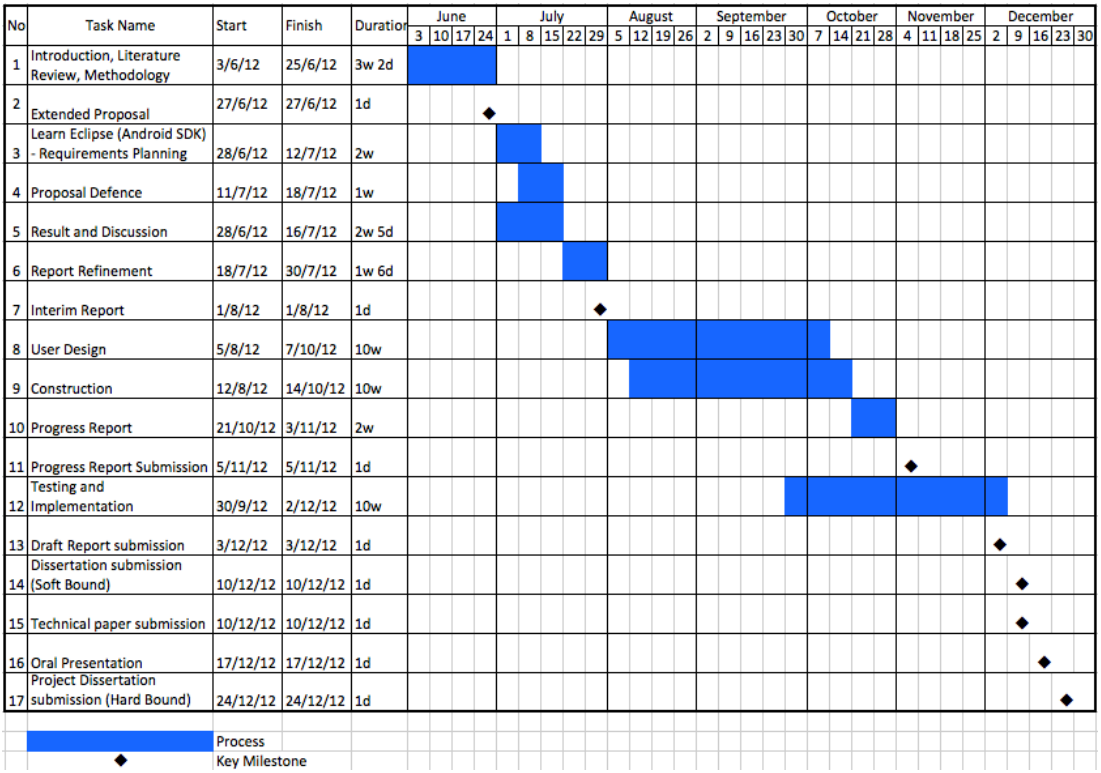

Figure 3.2 Gantt Chart and Key Milestone of Project

3.4 Tools Required

Types of hardware required in this project:

- Notebook (Macbook Pro OS 10.7.2) for application development.
- Android enabled tablet (Samsung Galaxy Tab 8.9) for usability testing.
- Graphic tablet (Genius EasyPen i405X) for graphic drawings.

Types of software required in this project:

- MIT App Inventor as the user interface design and prototype creation.
- Eclipse Indigo as the main development platform for the application.
- Pencil v0.4.4b software for the video animation creation.
- GIMP 2.8 for graphic editor.
- iMovie for video editing.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Project Deliverables

M-Math Story fulfills all the learning theory or model that suits children's learning capabilities. First of all, it is a mobile-learning application which can be accessed anywhere and at anytime that helps children to reapply the knowledge learnt in classrooms wherever they are comfortable with which meets the criteria mentioned by Sharples et al. (2009) and Sharma & Kitchen (2004). Secondly, it is trilingual, where children will have the preference language of their choice which facilitates better understanding as stated by Karen Kow (2003). This application includes multisensory techniques as it has multilanguage option, video tutorial, image representations, voice instructions, user involvement (touch), musical background, logical and mathematical concepts that covers the linguistic, auditory, visual and kinesthetic-tactile senses. Besides, user would be encouraged to use the trial and error method as proposed by Piaget (2008) in the exercises where they can try out the logic of mathematics by touching the images and watch them decrease or increase in amount.

The final version of the application is developed using Eclipse Indigo and it was used for the usability testing. The first two versions of the user interface design is shown under Appendix 7.1 and 7.2. This M-Math Story application will have 1 home screen and 4 main activities which consists of the mathematic operation option screen, video or exercise option screen, video tutorial activity and exercise activity. Throughout the application, there will be musical background to stimulate the mind of children and sustain their interest in learning more. The application is equipped with colourful layouts and graphics to capture the attention of children.

The homepage is as shown in Figure 4.1. It consists of an exit button to end the application and three main buttons that allows user options of English, Malay or Chinese language of the application. All three language option have the same academic content and story line. Each of the language button will link to their respective mathematic operation option page that includes the option of count, addition and subtraction. The mathematic operation page is as shown in Figure 4.2 which is in the English language version. The back button in this page links back to the homepage where user get to change the language of their choice.

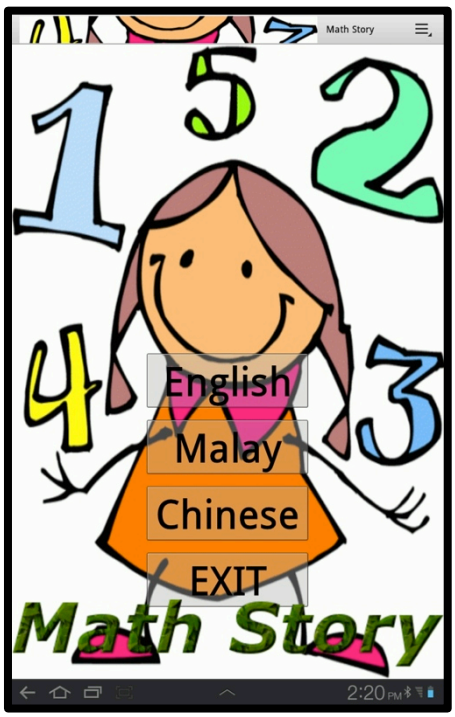

Figure 4.1 M-Math Story Home Screen

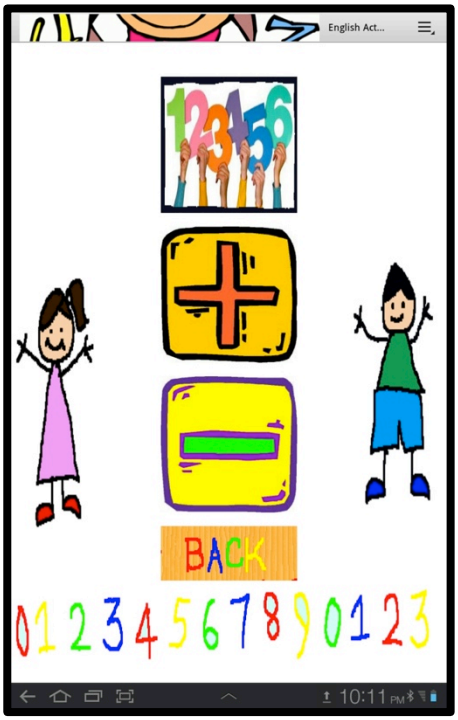

Figure 4.2 Mathematics Operation Option Screen

In each specific mathematic operation page, there will be two main functions which are the video tutorial and exercise option. The main focus of this video tutorial is to teach children the concepts of the particular mathematic operation in a story line and to solve problems related to that mathematic operation with visual and audio guidance. There are image representations, written narration as well as voice narration throughout the video. The exercise is to let children practice the lessons taught in the video tutorial and it is also in a story line to sustain the interest of children. Voice instructions are included in the exercises to assist those children with reading difficulties. Whenever a wrong answer is selected, they will be prompted to try again. Once the correct answer is selected, there will be words of encouragement to congratulate their effort in attempting the question. An example of the video or exercise option screen for one of the mathematical operation, count is as shown in Figure 4.3. The video tutorial activity in addition is as shown in Figure 4.4 and Figure 4.5 shows an example of the exercise activity in subtraction.

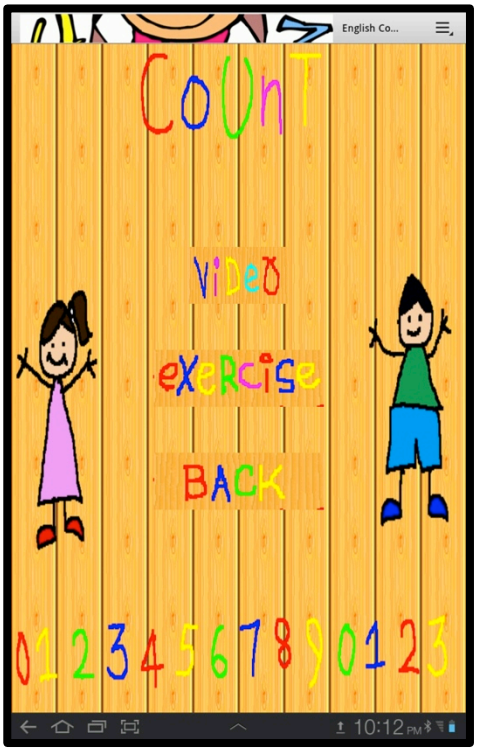

Figure 4.3 Video or Exercise Option Screen

Figure 4.4 Video Tutorial Activity Example in Addition

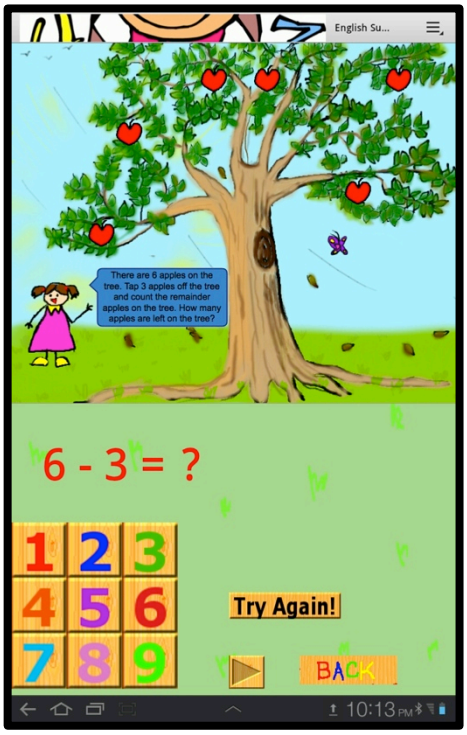

Figure 4.5 Exercise Activity Example in Subtraction

The graphic representations in both video and exercise activity for each of the different mathematic operation varies and the sample of the screenshots will be shown under Figure 4.7 Interface Flow Diagram.

Whenever user completes a set of exercise, there will be a congratulation page to acknowledge their ability to answer all questions correctly. Figure 4.6 shows the sample of the congratulation page on subtraction.

Figure 4.6 Congratulation Page

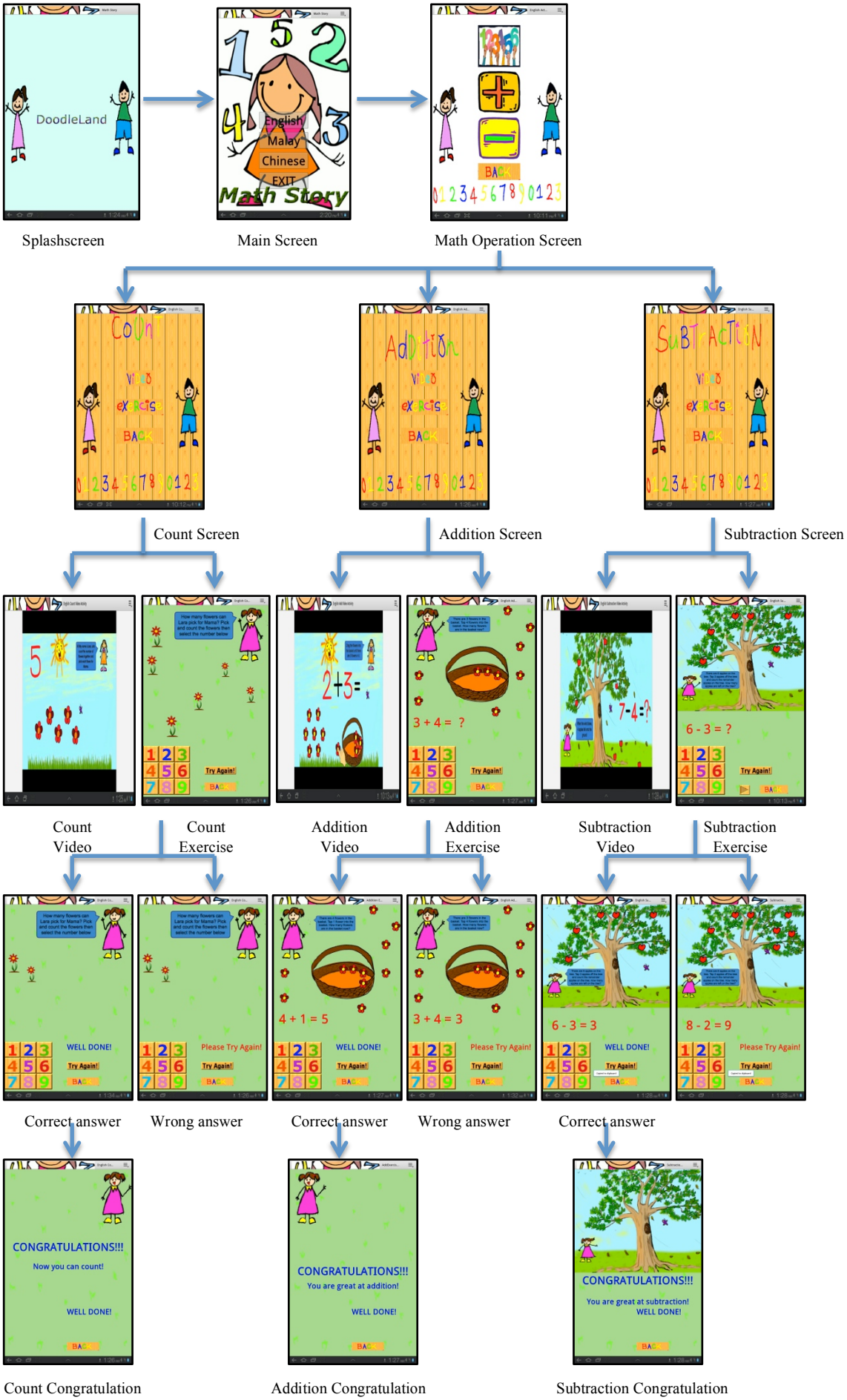

Figure 4.7 Interface Flow Diagram

4.2 Interview Results

To fulfill one of the objectives of the project, user testing has been conducted to test for the user acceptance rate as well as the usability of the application. The testing was done at random selected houses in Lee Rubber Village, Setapak Kuala Lumpur on Friday, 16th November 2012. 20 children have participated in this user testing and they are of age range four to six. Throughout the user testing, observation on users' reaction, facial expressions and actions were noted. After testing on the application, each children were interviewed and their opinion on the application were recorded. The interview questions were based on the Social Competence and Behavior Evaluation (SCBE) guideline designed by Peter J.L. to evaluate child's behavior on new environment. The template is as shown in Appendix 7.4. Data gathered throughout the user testing and interview session are analyzed and discussed in the following section. The interview questions were attached under Appendix 7.3.

4.2.1 Interview Analysis and Discussion

Each users have different level of knowledge on Mathematics and different level of understanding of the three languages available in the application that is English, Malay and Chinese. The first part of the interview aims to understand the age and background knowledge of each users, their pre-school involvement as well as current experience with mobile application. Children were asked on the level of understanding for each of the language that are available in the application followed by their current level of understanding on Mathematics.

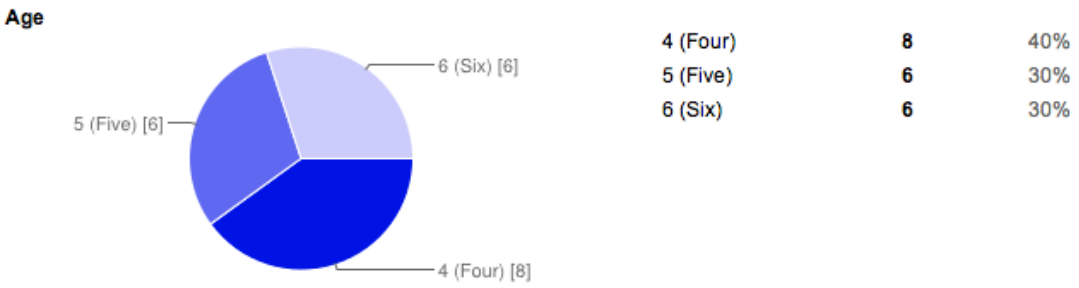

Figure 4.8 Age of Target Users

Figure 4.8 shows the age of the target users. The most number of users falls under age four which is 40% of the total users and there are equal number of users for age five and six which is 30% of the total users.

Next part of the interview aims to test the usability of the application and the overall interface, audio and graphic quality of the application.

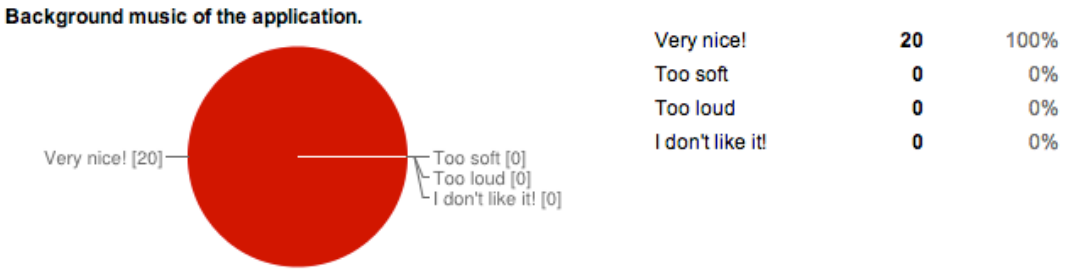

Figure 4.9 Background Music Acceptance

Figure 4.9 shows the response on the background music of the application. All users agreed that the background music of the application are suitable and very lively. Some children love to hum along with the song while testing on the application.

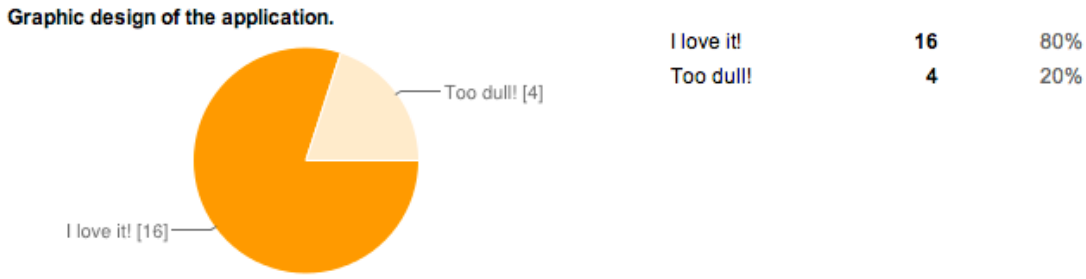

Figure 4.10 Graphic Design Acceptance

Figure 4.10 shows the response on the graphic design of the application which includes the layout, animation as well as images. 80% of the users love the graphic design of the application whereas 20% of the users find it too dull.

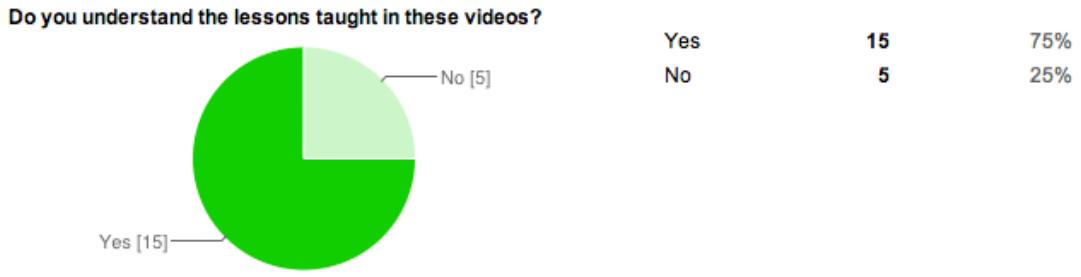

Figure 4.11 Video Understanding

Figure 4.11 shows the number of users that understand the lessons taught in the video. 75% of users understand the lessons taught in the videos and 25% cannot understand the lessons taught fully. The reasons for those who cannot understand completely based on the interview session are, the video were too fast, language barrier for those who do not understand one particular language and has chosen to watch the video on that language.

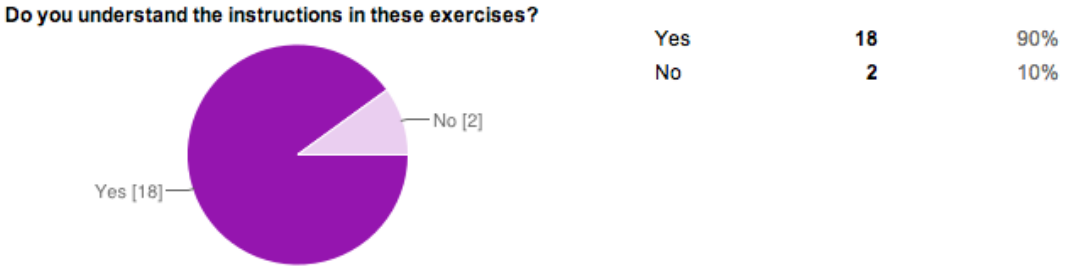

Figure 4.12 Instructions Clarity

Figure 4.12 shows the instructions clarity in the exercises. Users were asked whether they understand the meaning of the instructions in each question. 90% of users understand the instructions in the exercises however there are 10% that cannot follow up with the instructions in the exercises. The reason for this is the language barrier where they could not understand the language option that they have chosen due to lack of understanding in that particular language.

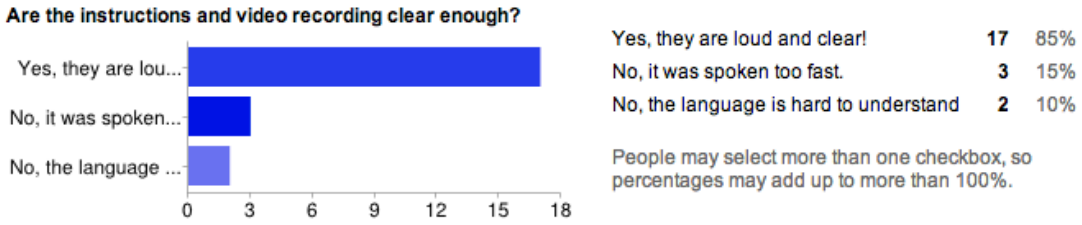

Figure 4.13 Auditory Quality

Figure 4.13 shows the auditory quality of the instructions in the exercises as well as the narration in the video tutorial. Users were asked whether the volume, speed of narration and words used are suitable. 85% of the users agreed that the instructions are loud and clear. 15% of users mentioned that the instructions were spoken too fast whereas 10% commented that the words used in the instructions are too hard for them to understand.

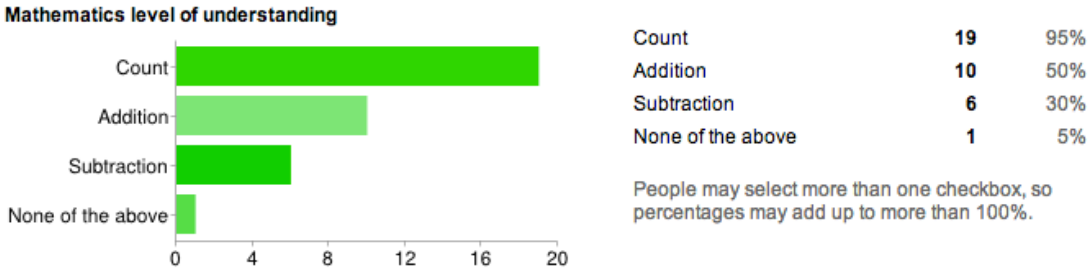

Figure 4.14 Mathematics Level of Understanding before Testing

Figure 4.15 Concepts Learned

Figure 4.14 and Figure 4.15 shows the Mathematics level of understanding of users before and after testing on the application respectively. Before testing, 95% of the users can count but after the user testing were done, 100% of the users mentioned

that they can now count. As for addition, before testing on the application, 50% have basic knowledge on addition, however after testing on the application, 90% of them can now add. Similarly for subtraction, before testing, only 30% of the users knows how to subtract and after they test out on the application, 80% of the users can now count. Overall, all users learnt something from this application as there is 0% response on "not learning anything from this application".

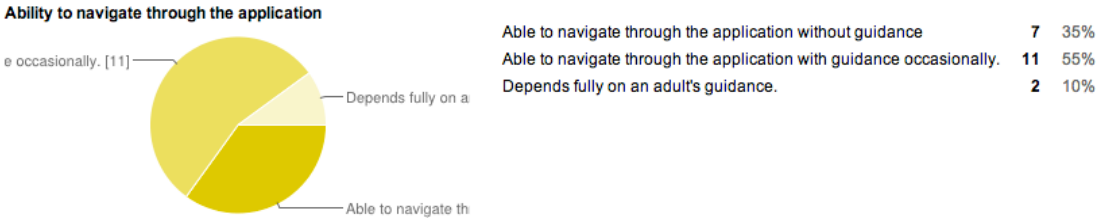

Figure 4.16 Ability to Navigate Through The Application

Figure 4.16 shows the ability of users to navigate through the application. 35% of users able to navigate through the application without guidance whereas 55% of the users needed guidance occasionally. 10% of the users depends fully on guidance. Some of these users does not have any experience with mobile application hence the high number of percentage for "with guidance occasionally".

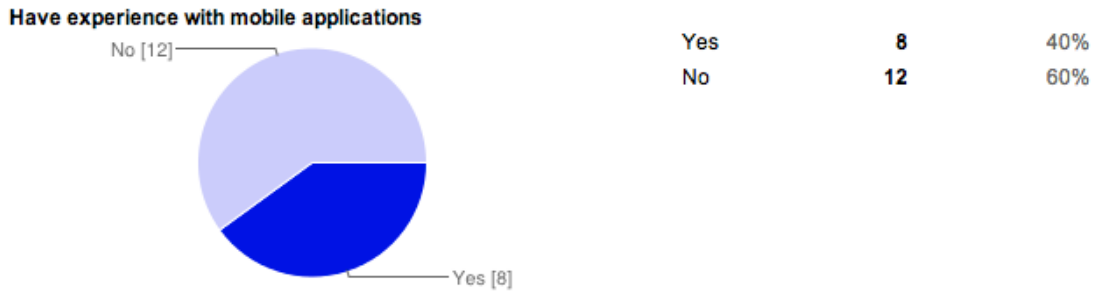

Figure 4.17 Users' Experience with Mobile Applications

Figure 4.17 shows the users' current experience with mobile applications. 40% of the users had experience with mobile applications before this whereas 60% of the users have not handle any mobile devices before.

Next part of the interview session aims to identify the user acceptance on the application and their eagerness in engaging themselves with the application.

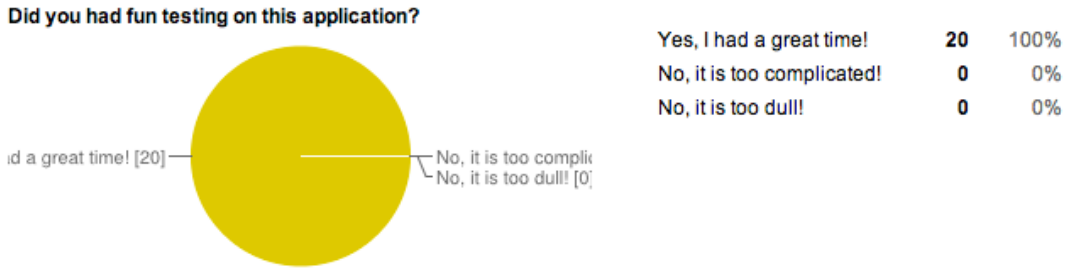

Figure 4.18 Users' Overall Response on Application

Figure 4.18 shows the overall response of users on the application. 100% of the users agreed that the application is fun and interactive. They enjoy testing on the application.

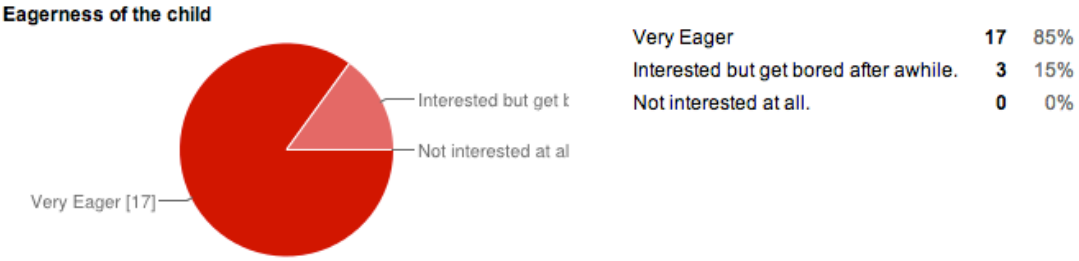

Figure 4.19 Eagerness of Children

Figure 4.19 shows the eagerness of the children while testing on the application. This criteria was judged by the author while observing the users throughout the testing. 85% of the users showed that they are very eager in testing on the application whereas only 15% were interested but get bored after testing on the application for some time. The reason for such behavior in these 15% of the users is the lack of knowledge on navigating through the application. Based on author's observation, children tend to be more eager in learning when they chose the language that they are comfortable with.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the literature review done, it can be concluded that the traditional method of teaching mathematics in classroom are no longer effective. The current trend is to embark the use of technology (m-learning) in education and to use multi-sensory techniques in approaching children's mobile learning application. Based on the results from the user testing, m-learning proves to capture attention of children and encourages them to reapply the knowledge learned in classrooms. Since that most of the children in pre-operational stage will not be able to perform mental operations, the teaching method should be of trial and error method where they get to test and experience for themselves the concepts of mathematics. The application has three language option for children to learn comfortably in their language preferences and it has proven through the user testing that children are more eager in learning when they chose the language they are comfortable with. The results from user testing on user acceptance and usability test are satisfying and supports the need to have such an application.

5.2 Recommendations

Further studies on the sustainability factors of the application has to be done to retain the eagerness of children in assessing the application like reward system and level upgrades. Besides, the story line can have more variation to it to build up the imaginative skills of children. Furthermore, more functionality such as tests or quizzes could be added in the application to evaluate the children's current level of understanding. It would be great to check thier progress each time the application is accessed and analyze whether there are any improvements to their current skill of mathematics.

Moreover, future research on personalizing the application according to users is recommended. Users are required to sign in to their own account to access the application. Whenever there are many users using the same application, their scores would not be mixed up with this functionality and it would be easier for tracking of progress. With this function, a database has to be connected with the application to store the personal scoring of each users.

Other than developing only on android platform, this application could also be developed on other mobile operating system such as the iOS for Apple products and Windows OS for Windows products. With that, more users get to benefit from this educational based application.

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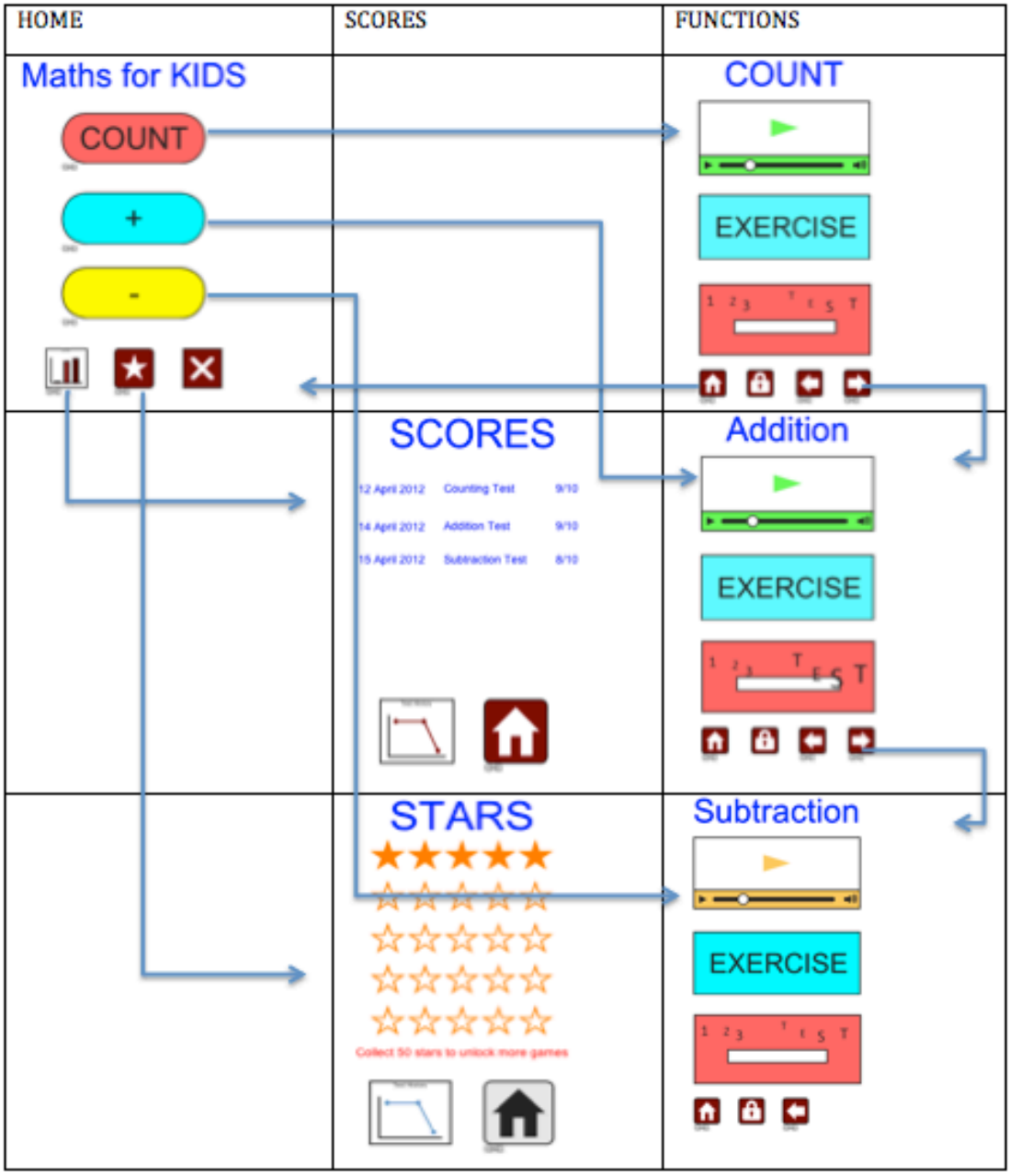
APPENDICES

7.1 First version of the user interface design:

Table 7.1 First Version of User Interface Diagram Flow



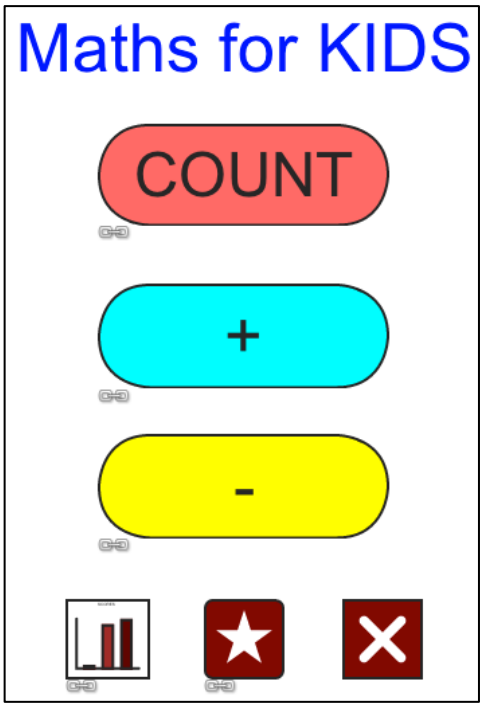


Figure 7.1 First Version Homepage

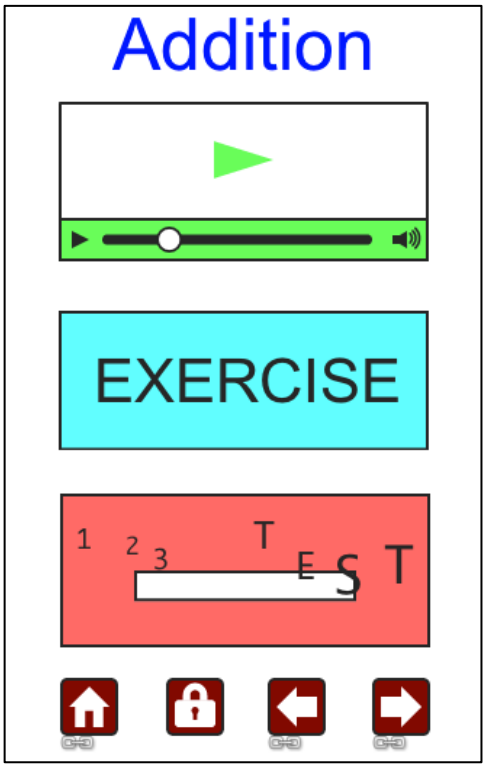


Figure 7.2 Addition Page

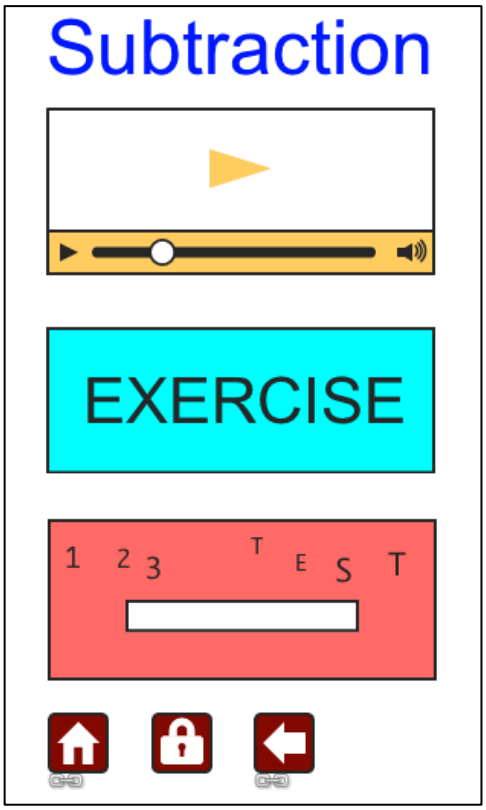


Figure 7.3 Subtraction Page

Figure 7.4 Score History Page

Figure 7.5 Stars Award Page

7.2 Second version of the user interface design:

Figure 7.6 Homepage

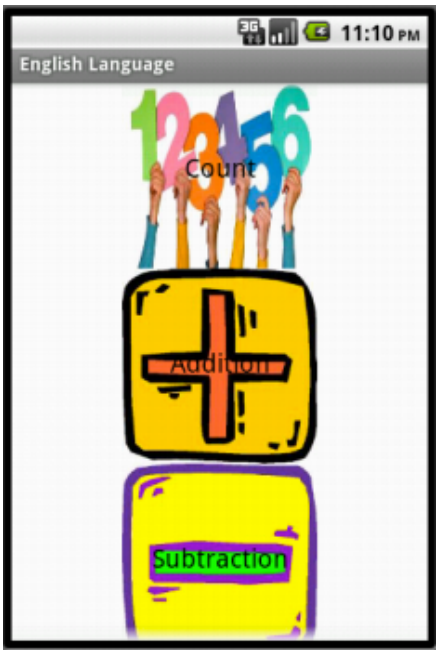
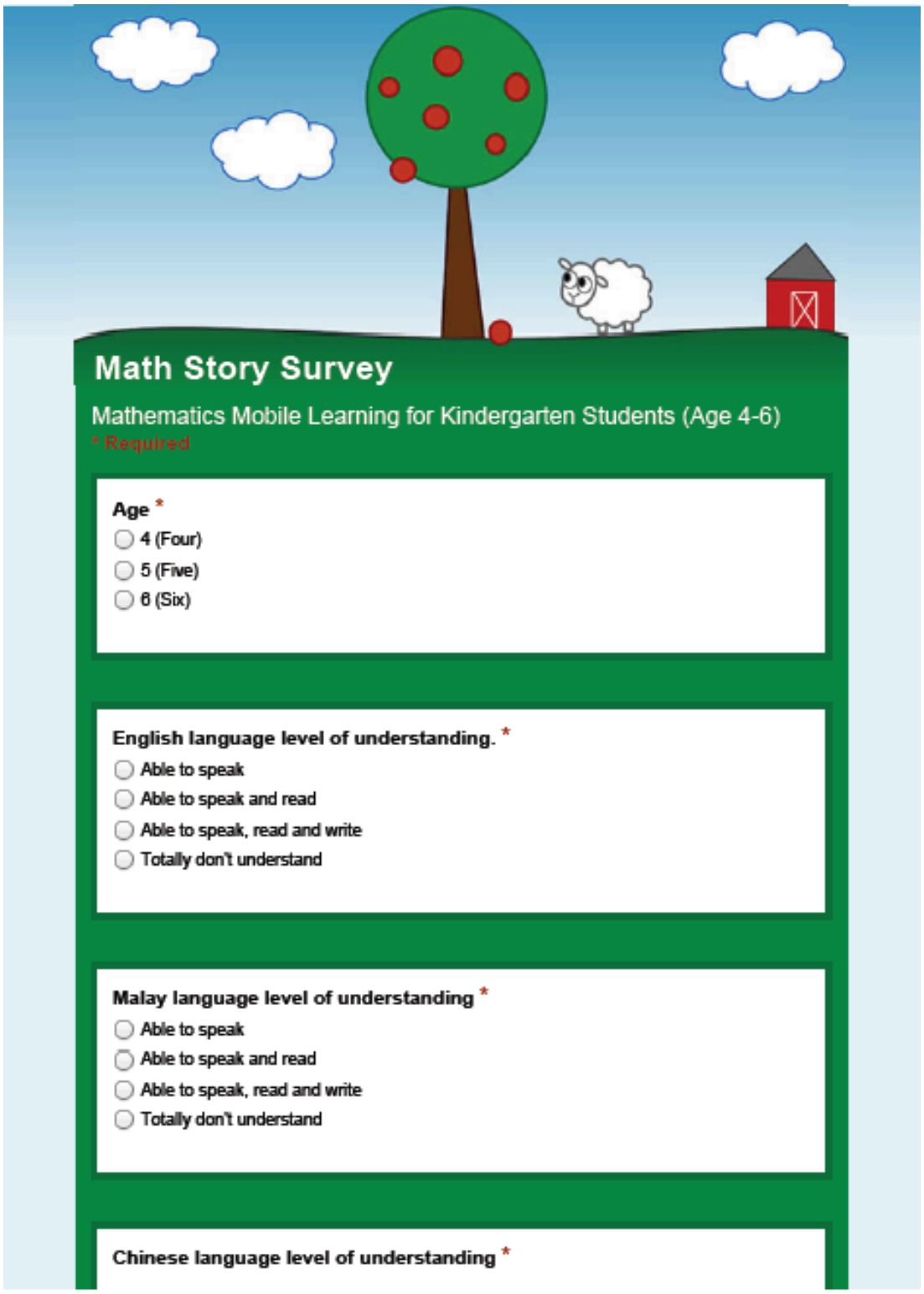


Figure 7.7 Mathematics Operation Option Page

Figure 7.8 Count page

Figure 7.9 Count Video Tutorial

7.3 Interview Questions:



Math Story Survey

Mathematics Mobile Learning for Kindergarten Students (Age 4-6)

* Required

Age *

- ◯ 4 (Four)
- ◯ 5 (Five)
- ◯ 6 (Six)

English language level of understanding. *

- ◯ Able to speak
- ◯ Able to speak and read
- ◯ Able to speak, read and write
- ◯ Totally don't understand

Malay language level of understanding *

- ◯ Able to speak
- ◯ Able to speak and read
- ◯ Able to speak, read and write
- ◯ Totally don't understand

Chinese language level of understanding *

- ◯ Able to speak
- ◯ Able to speak and read
- ◯ Able to speak, read and write
- ◯ Totally don't understand

Mathematics level of understanding *

- ☐ Count
- ☐ Addition
- ☐ Subtraction
- ☐ None of the above

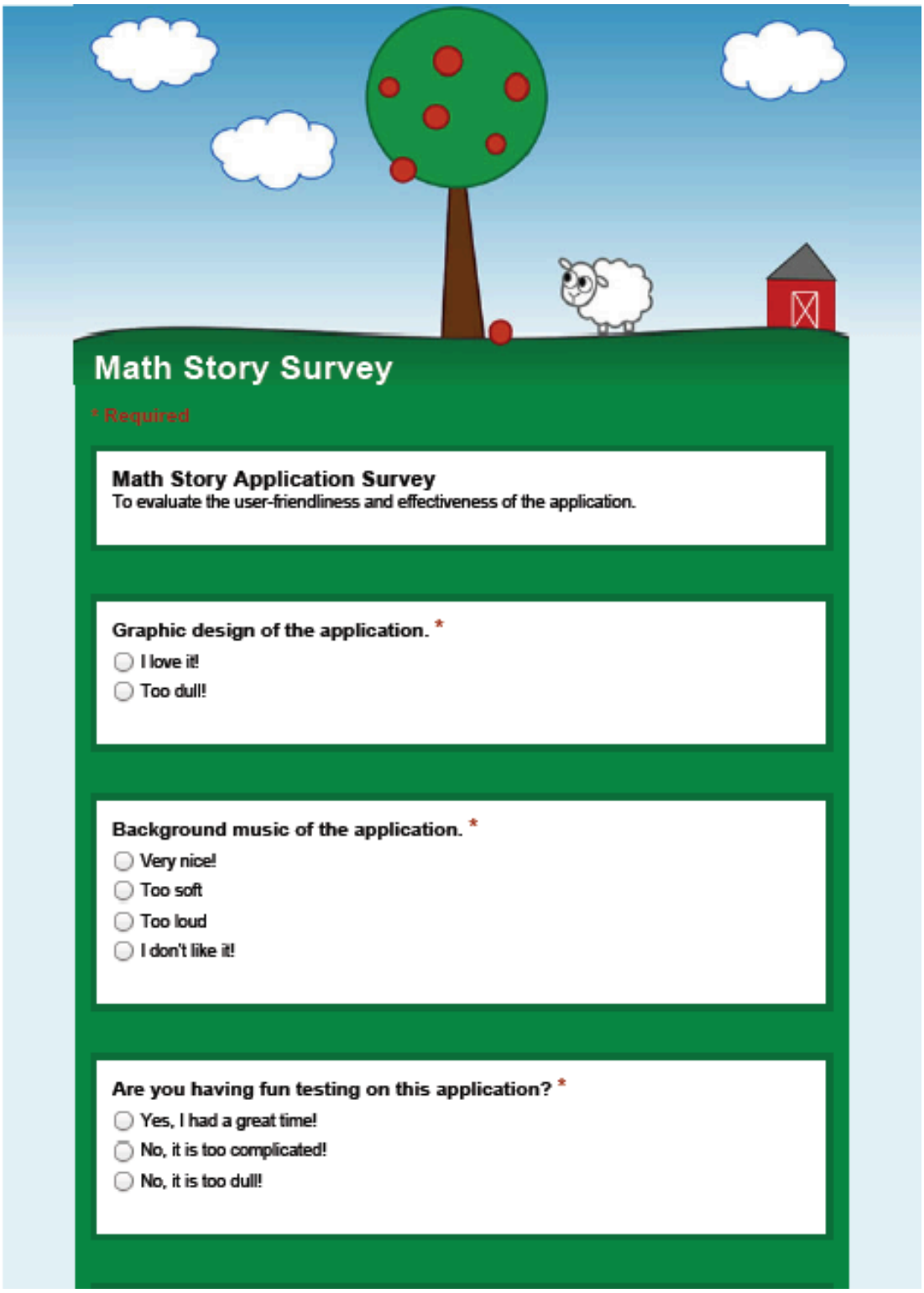
Preschool education involvement *

- ◯ Yes
- ◯ No
- ◯ Child care

Have experience with mobile applications *

- ◯ Yes
- ◯ No

Continue »


Math Story Survey
* Required
Math Story Application Survey
To evaluate the user-friendliness and effectiveness of the application.
Graphic design of the application. *
I love it!
Too dull!
Background music of the application. *
Very nice!
Too soft
Too loud
I don't like it!
Are you having fun testing on this application? *
Yes, I had a great time!
No, it is too complicated!
No, it is too dull!

Do you understand the lessons taught in these videos? *

Please state the video language that you understand and don't understand and the reason for your answer.

- ◯ Yes
- ◯ No

Do you understand the instructions in these exercises? *

Please state the type of exercise for whichever answer and the reason for your answer.

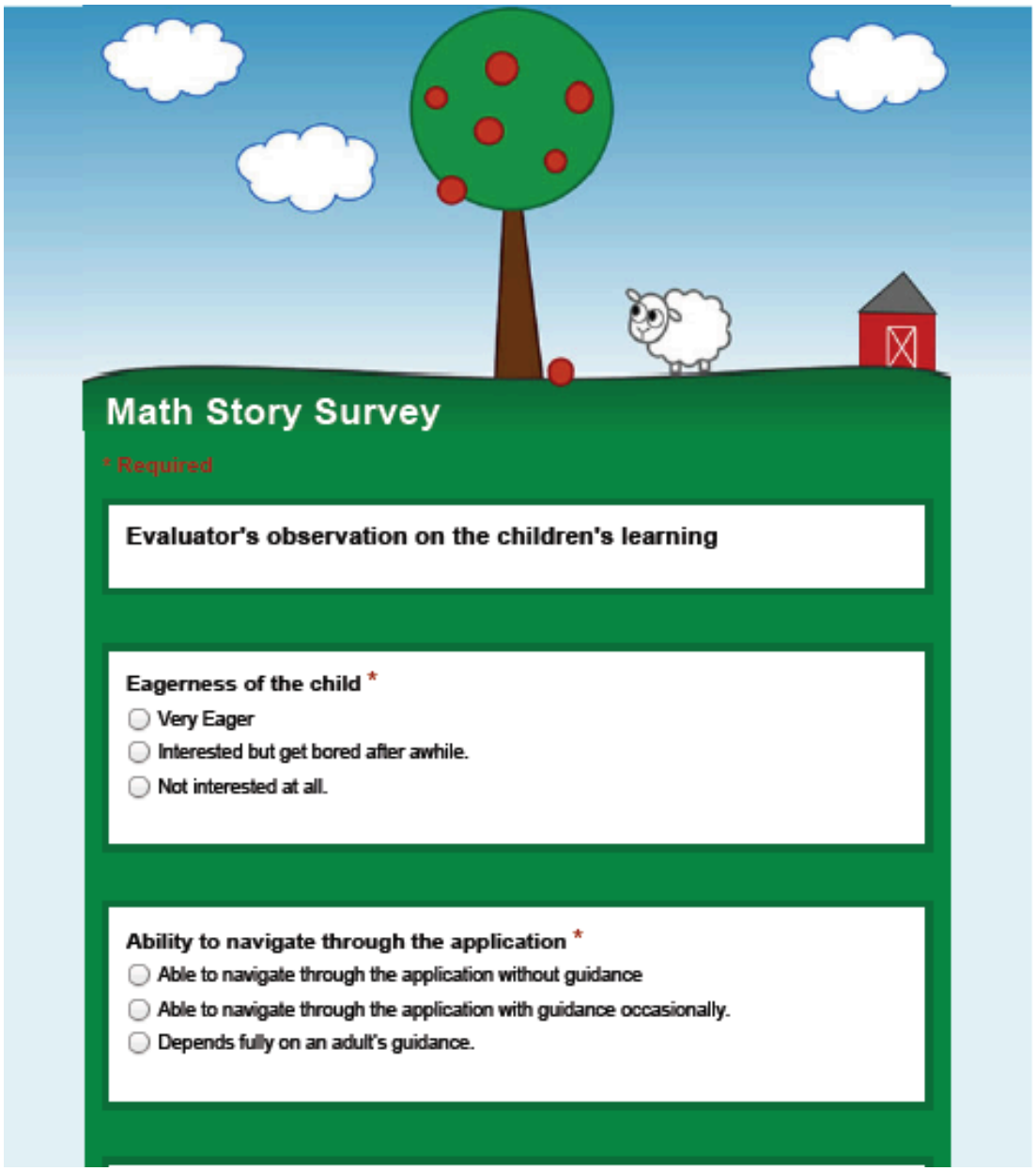
- ◯ Yes
- ◯ No

Are the instructions and video recording clear enough? *

- ☐ Yes, they are loud and clear!
- ☐ No, it was spoken too fast.
- ☐ No, the language is hard to understand

Did you learn something from this application? *

- ☐ Yes, now I know how to count.
- ☐ Yes, now I know how to add.
- ☐ Yes, now I know how to subtract.
- ☐ No, I did not learn anything from this application.


Math Story Survey
* Required
Evaluator's observation on the children's learning
Eagerness of the child *
Very Eager
Interested but get bored after awhile.
Not interested at all.
Ability to navigate through the application *
Able to navigate through the application without guidance
Able to navigate through the application with guidance occasionally.
Depends fully on an adult's guidance.

7.4 Social Competence and Behavior Evaluation (SCBE) guideline

Social Competence and Behavior Evaluation–Preschool Edition (SCBE) Peter J. LaFreniere, Ph.D.

Instructions

The following is a list of statements describing a child in three broad categories: emotional adjustment, social interactions with peers, and social interactions with adults. Use the following scale to rate the child by circling one choice for each statement to indicate the child's typical behavior or emotional state. Each of the ratings indicates how often a typical emotional state or behavior occurs:

Rating	Description
1	Almost NEVER occurs.
2 or 3	SOMETIMES occurs.
4 or 5	OFTEN occurs.
6	Almost ALWAYS occurs.

If you want to circle another number after you have made a choice for the same item, cross out your prior choice and circle another one. *Do not* erase the unwanted choice because it may damage the form.

Make every effort to assign a rating to each statement; leave an item blank only if you have no way of evaluating the child on that particular statement. If more than a few items are left without any rating, the results may not be meaningful.

Child's Name _____

Gender: ☐M ☐F Age ___yrs. ___mos. ID _____

School _____

Child's Class Teacher _____

Evaluator _____

Date of Evaluation _____

PLEASE PRESS HARD WHEN CIRCLING YOUR RESPONSE

	Never	Sometimes		Often	Always
1. Enjoys demonstrating new songs, games and other things he/she has learned.	1	2	3	4	5	6
2. Maintains neutral facial expression (doesn't smile or laugh).	1	2	3	4	5	6
3. Sensitive to another's problem.	1	2	3	4	5	6

7.5 User Testing at Lee Rubber Village houses, Setapak, Kuala Lumpur.

Trilingual Mathematics M-Learning for Kindergarten Students

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***Abstract*- Mobile-learning (m-learning) has been the current trend in this mobile age and education in technology has been a norm to students. This project aim to investigate the right method of learning mathematics effectively that leads to the development of an appropriate m-learning application for pre-school students of age four to six. The main objectives of this project are to develop a trilingual mathematic m-learning application for pre-school students that help boost learning innitiatives and to perform user testing on the m-learning application developed. The mathematical concepts that are included in this application are count, addition and subtraction. The development approach for this project is the Rapid Application Development (RAD) model as it has rapid prototyping features and could be developed iteratively according to users' needs and expectation. Eclipse Indigo is the main development platform for this m-learning application. Based on the user testing, this application has gained full recognition from targeted users.**

I. INTRODUCTION

A. Background of Study

Using technology in education has been a great help in anticipating student's participation in learning. It is a platform to practice the syllabus they learnt in schools for better memory enhancement and application of knowledge acquired. Technology in education has been widely implemented especially in mathematics. According to National Council of Teachers of Mathematics (NCTM), technology is an essential tool for learning Mathematics in the 21st century [1].

In this mobile age, more than half of the world's population now owns a cellphone and children under 12 is the fastest growing segments of mobile technology users in the U.S [2]. Mobile learning (m-learning) is the implementation of technology in education on the move where learning takes place in different location, time or context. M-learning helps accessing of knowledge more efficient and effective to an individual as they could easily seek knowledge with the existence of a mobile device. This mobile device could be a smartphone, PDAs, iPods, iPads, tablets or any other educational portable device.

Mathematics should be taught to children since young to instill their interest in it and to shape the basic foundation of mathematics. Children of age four to six have different learning approaches as compared to primary or secondary school students. While going through this stage, children could not perform mental operations very well as they prefer experimenting with the new knowledge gained and form their own hypothesis out of it. Hence, to approach children in this stage, a right method has to be considered to make learning easier and more engaging for them. Thus, the research on this project is to develop a suitable learning platform for these children to acquire knowledge at their optimum ability. The proposed learning platform in learning mathematics effectively for kindergarten students is a trilingual mathematics mobile application (M-Math Story) that focuses on the multisensory techniques.

B. Problem Statement

Not every child has the same level of mental readiness although they are of the same chronological age [3][4]. Children have different capabilities of acquiring the mathematical concepts [5]. As a result of this different level of mental maturity in children, kindergarten teachers are having difficulties in introducing mathematical concepts merely by classroom presentations. Students at various developmental level and differing learning capabilities can be left behind while the teacher continues on the next lesson [17].

There is lack of local material for children in the market. The current applications in Google Play and iTunes market does not cater to the malaysian context. There are no single application for children that is in three languages; malay, chinese and english for children of malaysia.

Students of age four to six have a very short attention span. They tend to fidget around and could not focus for long period while learning in a closed-up area. They need something more interactive, engaging and fun to promote learning and something which is mobile rather than having to stay still in a classroom setting.

Nowadays, parents are too occupied to spend time with their children. Hence letting children explore with their smartphones is a common way to keep them occupied while they are handling their busy lifestyle. Not just any applications are suitable for these children. The right application will help them learn at the same time keep them occupied for longer period of time while parents are busying.

C. Significance of Project

This project discovers the right methods of learning mathematics effectively and indulge children's interest in mathematics at an early stage. Learning mathematics effectively can be further enhanced by using multi-sensory techniques in the learning process. This could be a mixture of visual, auditory, touch and kinesthetic-tactile sensory that could help stimulate the mind of children and capture their attention. M-Math Story is a trial and error type of m-

learning application that focuses on linguistic, logical and mathematical, musical, visual-spatial and kinesthetic (touch) senses. M-Math Story also provides scenario-based situation for children to visualize the real situation that may occur in life.

Most importantly is the functionality that is available in this application where children will be exposed to video tutorial of the mathematical concepts followed by some exercises for users to practice and enhance their level of understanding. The video tutorial teaches children step by step on how to solve a particular mathematic problem and the use of visual and auditory aid enhances memory capability. The exercises enable children to use the trial and error method to understand the concepts of the subject and visualize the real situation.

Besides, this application caters to the three main languages mostly spoken by Malaysians, which are the Malay, English and Chinese language. This is to ensure that students get to learn comfortably in their mother tongue language. Moreover, they can even learn more than one language instead of just grasping the concepts of mathematics.

D. Objectives of Study

The objectives of this research are outlined as the following:

- To research on a suitable method for children to learn mathematics.
- To develop a trilingual mathematics m-learning application for pre-school students that helps boost learning innitiatives as well as improving their memory capability.
- To perform user testing on the m-learning application developed.

E. Scope of Study

TABLE I
SCOPE OF STUDY

Target Group	Focus Topic	Approach
Preschool students age four to six years old in Setapak, Kuala Lumpur housing area.	Mathematics on basic operation of count, addition and subtraction.	Multisensory technique which involves linguistic, visual, auditory and kinesthetic (touch senses)

II. LITERATURE REVIEW

A. Children and Technology

Research shows that the use of technology in education enhances children's fine motor skills, alphabet recognition, concept learning, numerical recognition, counting skills and pre-mathematical knowledge, cognitive development, and self-esteem or self-concept [6]. Home computer use enhances children's visual intelligence skills, such as the ability to read and visualize images in 3-dimensional space and trace multiple images simultaneously [7]. Frequent practice of technology in home and community settings by young children may influence their early literacy no less than any other purposeful learning [8][9]. Indirectly, children would be able to grasp the concepts of mathematics as well as literacy while having fun.

National Council for Teachers of Mathematics has several goals and one of the main goals is to create a vision for mathematical literacy in an increasingly technological world, which requires application of skills and knowledge across diverse disciplines [10]. This goal supports the need to have a mobile learning application for pre-school students that covers multi-sensory techniques on learning mathematics.

Children that uses educational software in an informal, collaborative context learned content knowledge about computer literacy, became more proficient in focusing on main aspect of instructions, developed planning strategies for learning new games and also improves in basic academic skills. They also reported that these students outperformed their peers who did not participate by having greater levels of improvement in their performance on basic reading and mathematics achievement standardized tests [11].

B. Mobile Learning and Education

M-learning is that it is an extension of e-learning with mobile devices such as cell phones, PDAs, and iPods as the main device for learning [12]. The transition of e-learning to m-learning is a revolution as it includes the change in terminology and mindset in the process of designing and planning learning outcome and goals [13]. The advantage of using the mobile technology in learning is that learning of the contents could be done dynamically dependent on the learner's location, context and device [14].

Reapplication of knowledge that was gained earlier in classroom in a different context could help learner remember the knowledge for a lifetime [15]. M-learning has became more prominent in the lives of children around the globe and there has been an innitiative between the national ministries and local schools in experimenting the use of these devices in the teaching and learning industry [16].

C. Model / Theory best suit children's learning capabilities

There are several stages of mental readiness in children. These stages are the sensorimotor, pre-operational, concrete operational and formal operational. Sensorimotor stage are usually infants from birth to approximately two years of age whereas pre-operational ranges from two to seven years old. Concrete operational and formal operational are from seven to eleven and twelve to thirteen years of age respectively. These are just rough approximation of time frame on which the children enter each stage as each individual have different developmental level however the order of these stages are universal [5]. The stage that will be focused in this paper is the pre-operational stage.

Children of pre-operational stage are from the age group of two to seven. In this phase of life, a child does not have the capability to perform the mental activities Piaget called "operations" [5]. One of these operations closely related to learning the mathematics concepts is the conservation of quantity where the quantity of something remains the same although there has been changes to the order of appearance [17]. Children of this stage could not distinguish the similarity of the quantity of something after it has been repositioned. Furthermore, they would have an egocentric

perspective of thinking as they tend to be more self-centered and have difficulty accepting other views but their own [18].

Without correct teaching tools and methods, the child who needs extra attention in acquiring the knowledge may be left behind and the basic concepts of mathematics will never be understood [17] resulting in slower learning progress as well as unattentiveness in learning. Thus, what they proposed in their paper is multi-sensory teaching techniques which involves more than one senses in the elementary teaching.

A combination of visual, auditory, kinesthetic (touch) and emotional may increase children attentiveness in learning. They do not stay focus on one single activity if it is not captivative and will tend to lose focus and skip learning that subject. Therefore, there is a need to look for alternative to the traditional teaching methods of mathematics. The use of technology in mathematics has shown an increase in mathematical achievement of children in pre-school and primary grades [19].

D. Trilingual Education

Children are able to grasp the concepts and remember different languages words and pronunciation if they can learn different language with the same image, which enhance their connection with different language, thus improving their memory. This emerging mobile technologies era provide greater language learning solutions in an interactive, pervasive and convenient way [20]. Children learn different languages even better on mobile applications. Hence if mobile learning is to be conducted in multiple languages, children will be able to learn the additional language and the mathematical concepts at the same time.

Code switching is often implemented in multiracial countries like Malaysia where Malaysians use it as a sociolinguistic tool as a means of communication aid rather than obstruction to communication [21]. Code switching means moving from one language to another with the same speaker [22]. There are many reasons to code switching. Based on a study to examine the ways code switching is employed by pre-school Malaysian children done, there are 9 conditions where code switching is favorable [23]: (1) Lack of one word in either language; (2) Some activities have only been experienced in one of the languages; (3) Some concepts are easier to express in one of the languages; (4) A misunderstanding has to be clarified; (5) One wishes to create a certain communicative effect; (6) One continues to speak the language latest used because of the trigger effect; (7) One wants to make a point; (8) One wishes to express group solidarity; (9) One wishes to exclude the another person from the dialogue. Pre-school children may not have a good grasp over language, hence different language options helps provide greater scope of explanation and wider opportunity for understanding.

E. Existing Mathematics M-Learning Application

"My Math Flash Cards App" is one of the applications found in the i-Tunes store where it is developed by Pankaj Humad in 2010 [24]. The features in this application includes four basic operations of mathematics which are the addition, subtraction, multiplication and division. The function of the application is to randomly generate flash cards with questions for students to answer. The specialty is that users could customize which particular fact to focus on. For example if user pick number 2 to be the focus fact, then the maths operations on the number 2 would be emphasized on. It is purely static and does not have animation graphic which would be dull and uninteresting for children. Besides, it is less interactive as compared to other children application.

Other application from the i-Tunes store is an application called "Math is Fun: Age 4-5 (Free)". This application has 8 fun activities which teaches kids on how to recognize numbers, count, order numbers, play with weight, determine ranking and handle shapes [25]. The main features of this application are simple and children-friendly game design plus high quality graphics and animations. This application does not include any video teaching or concepts of how this activities works. It is just pure questions without assessment.

There are many more applications in the android market and i-Tunes store however non of them have video teaching on the mathematical concepts. There are no application with trilingual option as well. The common functions among those applications are exercises and picture representation of the mathematic concepts.

III. METHODOLOGY

A. Research Methodology

The main research methodology that would be used in this project is the Rapid Application Development (RAD) model as shown in Figure 1. This methodology is chosen due to the rapid prototyping nature where development of the application could be done in the early stage and users' needs and expectations could be addressed at the development phase. This method is flexible and adaptable to changes reducing the overall project risk.

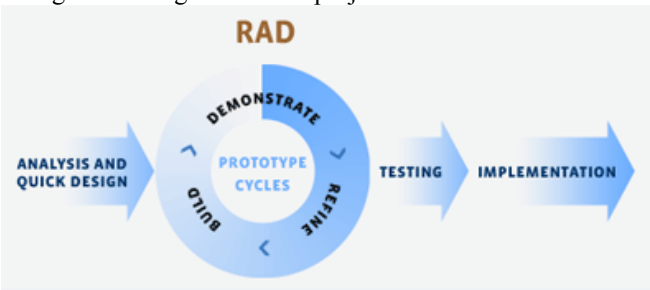

FIGURE 2: Rapid Application Development (RAD) methodology

B. Project Activties

This project undergo several phases. Table II shows the detailed process of each phase.

TABLE II
PHASES IN RAD MODEL OF THE PROJECT

Phase 1 – Analysis and Quick Design
The purpose of the project is defined and detailed research is carried out to gather the basic information required to develop the application. The gantt chart and key milestone is properly planned to keep the development of project on track. First draft of the interface of the application is designed using the MIT App Inventor to see the logic and functions that should be included.

Phase 2 – Prototyping Cycles
Build This stage is the innitial development of the prototype on the MIT App Inventor to have an animated view of the design. **Demonstrate** The prototype would be demonstrated to supervisor for feedbacks and ideas for improvements. It would also be demonstrated to a few selected children in the age range of 4-6 to get their response on the application. **Refine** Update and improve on the application based on feedbacks from users and supervisor to meet their needs and expectations.
Phase 3 – Testing
Once the application has been improved, enhanced and refined, usabilty test and user accpetance test was conducted with the children at the targeted user location. This is to ensure that the application is fully accepted by children and is user-friendly.
Phase 4 - Implementation
A complete working was launched into the Google Play market for wider range of children to use and benefit from this m-learning application.

C. Tools Required

The tools used to develop this project are as follows:

- Notebook for application development.
- Android enabled tablet for usability testing.
- Graphic tablet for graphic drawings.
- MIT App Inventor as the interface design creation.
- Eclipse Indigo as the main development platform.
- Pencil v0.4.4b for the video animation creation.
- GIMP 2.8 for graphic editor.
- iMovie for video editing.

IV. RESULTS AND DISCUSSION

A. Project Deliverables

M-Math Story fulfills all the learning theory or model that suits children's learning capabilities. First of all, it is a mobile-learning application which can be accessed anywhere and at anytime that helps children to reapply the knowledge learnt in classrooms wherever they are comfortable with which meets the criteria mentioned by author in Ref. no. [15] and [14]. Secondly, it is trilingual, where children will have the preference language of their choice which facilitates better understanding as stated by author in Ref. no. [25]. This application includes multisensory techniques as it has multilanguage option, video tutorial, image representations, voice instructions, user involvement (touch), musical background, logical and mathematical concepts that covers the linguistic, auditory, visual and kinesthetic-tactile senses. Besides, user would be encouraged to use the trial and error method as proposed by Piaget in the exercises where they can try out the logic of mathematics by touching the images and watch them decrease or increase in amount.

The final version of the application is developed using Eclipse Indigo and it was used for the usability testing. This M-Math Story application will have 1 home screen and 4 main activities which consists of the mathematic operation option screen, video or exercise option screen, video tutorial activity and exercise activity. Throughout the application, there will be musical background to stimulate the mind of children and sustain their interest in learning more. The application is equipped with colourful layouts and graphics to capture the attention of children.

The home screen as shown in Figure 2 consists of an exit button to end the application and three main buttons that allows user options of English, Malay or Chinese language of the application. All three language option have the same academic content and story line. Each of the language button will link to their respective mathematic operation option page that includes the option of count, addition and subtraction.

In each specific mathematic operation page, there will be two main functions which are the video tutorial and exercise option. The main focus of this video tutorial is to teach children the concepts of the particular mathematic operation in a story line and to solve problems related to that mathematic operation with visual and audio guidance. There are image representations, written narration as well as voice narration throughout the video. The exercise is to let children practice the lessons taught in the video tutorial and it is also in a story line to sustain the interest of children. Voice instructions are included in the exercises to assist those children with reading difficulties. Whenever a wrong answer is selected, they will be prompted to try again. Once the correct answer is selected, there will be words of encouragement to congratulate their effort in attempting the question. Sample of Exercise screen is as shown in Figure 3.

Whenever user completes a set of exercise, there will be a congratulation page to acknowledge their ability to answer all questions correctly.

FIGURE 2: Home Screen

FIGURE 3: Exercise Screen

B. Interview Results

To fulfill one of the objectives of the project, user testing has been conducted to test for the user acceptance rate as well as the usability of the application. The testing was done at random selected houses in Lee Rubber Village, Setapak Kuala Lumpur on Friday, 16th November 2012. 20 children have participated in this user testing and they are of age range four to six. Throughout the user testing, observation on users' reaction, facial expressions and actions were noted. After testing on the application, each children and their parents were interviewed and their opinion on the application were recorded. The interview questions were

based on the Social Competence and Behavior Evaluation (SCBE) guideline designed by Peter J.L. to evaluate child's behavior on new environment. Data gathered throughout the user testing and interview session are analyzed and discussed in the following section.

Each users have different level of knowledge on Mathematics and different level of understanding of the three languages available in the application that is English, Malay and Chinese. The first part of the interview aims to understand the age and background knowledge of each users, their pre-school involvement as well as current experience with mobile application. Children were asked on the level of understanding for each of the language that are available in the application followed by their current level of understanding on Mathematics. The interview also covers the overall interface, audio and graphic quality of the application. Overall acceptance on the above criteria is above average.

Figure 4 shows the number of users that understand the lessons taught in the video and Figure 5 shows the children's understanding of instructions in the exercises. 75% of users understand the lessons taught in the videos and 25% cannot understand the lessons taught fully whereas 90% of users understand the instructions in the exercises while 10% don't. The reasons for those who cannot understand completely based on the interview session are, the video were too fast, language barrier for those who do not understand one particular language and has chosen to watch the video on that language.

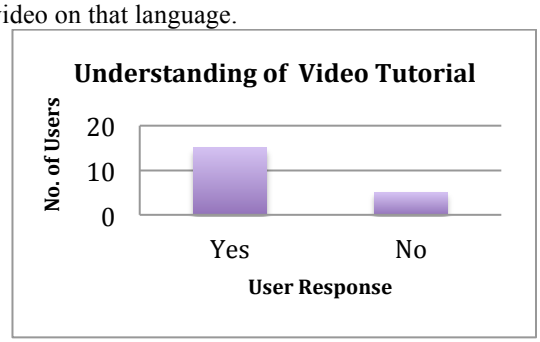

FIGURE 4: Children's understanding on the Video Tutorials

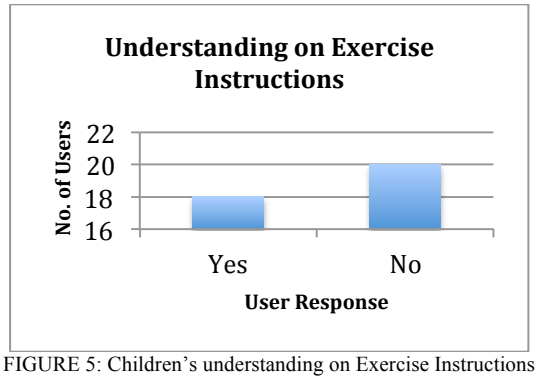

FIGURE 5: Children's understanding on Exercise Instructions

Figure 6 shows the ability of users to navigate through the application. 35% of users able to navigate through the application without guidance whereas 55% of the users needed guidance occasionally. 10% of the users depends fully on guidance. Some of these users does not have any experience with mobile application hence the high number of percentage for "with guidance occasionally".

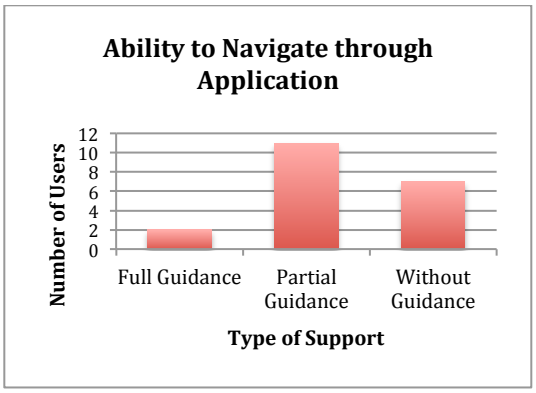

FIGURE 6: Children's Ability to Navigate Through Application

Figure 7 shows the eagerness of the children while testing on the application. This criteria was judged by the author while observing the users throughout the testing with SCBE guideline. 85% of the users showed that they are very eager in testing on the application whereas only 15% were interested but get bored after testing on the application for some time. The reason for such behavior in these 15% of the users is the lack of knowledge on navigating through the application. Based on author's observation, children tend to be more eager in learning when they chose the language that they are comfortable with.

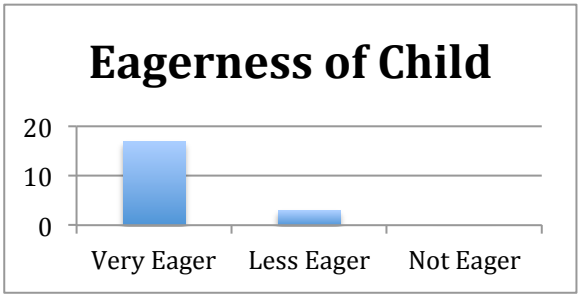

FIGURE 7: Child's Eagerness while Handling Application

V. CONCLUSION AND FUTURE WORK

Based on the literature review done, it can be concluded that the traditional method of teaching mathematics in classroom are no longer effective. The current trend is to embark the use of technology (m-learning) in education and to use multi-sensory techniques in approaching children's mobile learning application. Based on the results from the user testing, m-learning proves to capture attention of children and encourages them to reapply the knowledge learned in classrooms. Since that most of the children in pre-operational stage will not be able to perform mental operations, the teaching method should be of trial and error method where they get to test and experience for themselves the concepts of mathematics. The application has three language option for children to learn comfortably in their language preferences and it has proven through the user testing that children are more eager in learning when they chose the language they are comfortable with. The results from user testing on user acceptance and usability test are satisfying and supports the need to have such an application.

Further studies on the sustainability factors of the application has to be done to retain the eagerness of children

in assessing the application like reward system and level upgrades. Besides, the story line can have more variation to it to build up the imaginative skills of children. Furthermore, more functionality such as tests or quizzes could be added in the application to evaluate the children's current level of understanding. It would be great to check thier progress each time the application is accessed and analyze whether there are any improvements to their current skill of mathematics.

Moreover, future research on personalizing the application according to users is recommended. Users are required to sign in to their own account to access the application. Whenever there are many users using the same application, their scores would not be mixed up with this functionality and it would be easier for tracking of progress. With this function, a database has to be connected with the application to store the personal scoring of each users.

Other than developing only on android platform, this application could also be developed on other mobile operating system such as the iOS for Apple products and Windows OS for Windows products. With that, more users get to benefit from this educational based application.

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