Number Skills Mobile Application for Down Syndrome Children

By

Hidayatun Nafisah Binti Isa Muddin

Dissertation submitted in partial fulfillment of

the requirement for the

Bachelor of Technology (Hons)

(Information & Communication Technology)

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CERTIFICATION OF APPROVAL

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Approved by,

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

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

September 2013

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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HIDAYATUN NAFISAH BINTI ISA MUDDIN

ABSTRACT

Studies found that learning number skills seems to be more difficult for Down Syndrome (DS) children compared to reading skills. They need personalized learning in numbers due to their slower pace of learning. Unfortunately, there is limited theory to guide DS children to learn and master in mathematics. Besides that, with the advancement of technology, the learning style of special children has been improved from time to time from the paper and pen method, to the use of computer application such as courseware, and the latest technology is mobile application in smart phones and tablets. But, as for now, there is no personalized mathematics learning mobile application for DS children. To address this problem, the aim of this project is to develop a mobile application on learning the basic numbers for Down Syndrome children, with the objective of identifying the suitable learning theory to be used in developing numeracy conceptual framework for them. The other objective is to evaluate the user acceptance on the developed mobile application at the last phase of the project development. The study will be focusing on the Down Syndrome children with moderate level of IQ who are learning to recognize basic numbers. In this project, the method used to achieve the objectives is Rapid Application Development (RAD). The phase of requirement planning was done through interview, research and literature review study on gathering information about Down Syndrome, learning theories and the suitable development platform for the application. For user design phase, the suitable learning theory has been designed, the draft as well as the flow of suitable user-interface has been created. The construction part involved activities of developing and validating the mobile application, and user acceptance test. Lastly, after conducted a user testing to DS children who have different level of IQ, the result shows that the mobile application is really suitable for DS children who have moderate level IQ as stated in the scope before. This is because it is able to assist them in understanding basic numbers through the process of learning mathematics based on the learning theory included in the application learning style.

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"With the Name of Allah the Most Merciful and the Most Gracious"

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ABBREVIATIONS AND NOMENCLATURES

ADT	Android Development Tool
DS	Down Syndrome
FYP	Final Year Project
KDSC	Kiwanis Down Syndrome Center
OS	Operating System
RAD	Rapid Application Development

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Down Syndrome (DS) is a common chromosomal abnormality that happened because of an error that occurs in cell division that results in an extra 21st chromosome. One of the researches (Crosta, 2009), stated that women who are 44 years and older faced the higher risk of having baby with a chromosome problem such as Down Syndrome. DS children can be recognized by their physical characteristics such as a small nose with flat nasal bridge, a small mouth, eyes that slant upwards and outwards, wide hands and short fingers, hypotonia and many more. They also have cognitive delays that cause them to take longer time to learn, sit, walk and talk compared to normal people.

Studies found that DS children seem to have more difficulties in learning number skills compared to reading skills. They need personalized learning in numbers due to their slower learning pace. Therefore, the learning outcomes of mathematics curriculum for DS children should be realistic and suitable to their capabilities. This is because such appropriate and useful skill especially in number can support them to be independent in real life. Before this, several methods of teaching using pen and papers, flash cards and courseware have been used to teach DS students in learning numbers and mathematics. Now, with the advancement of technology, new learning tools, devices and gadgets have been introduced for education purposed especially for special children. Compared to those traditional ways of learning, animated material allows the children to extend their

attention span a little bit longer as they usually have better visual skills than listening skills.

DS children have different level of IQ. Some of them even do not know how to speak and interact, but some are really intelligent and can learn well. The scope of this project is DS children with moderate level of IQ who are learning to recognize basic numbers using the approach of touch screen mobile devices such as tablets and mobile phones. Moderate level means that the DS children understand what other people instruct and said to them, and at the same time have interest in learning. Thus, developing an interactive mobile application with the right and suitable learning theory for them would be something new and can keep their interest going in learning mathematics, besides boosting their understanding skills in knowing numbers.

1.2 Problem Statement

The problem statements of this project are:

1) There is limited theory to guide Down Syndrome children to learn and master in mathematics
2) There is no personalized mathematics learning mobile application for Down Syndrome children

For the first problem statement, it is important to develop a proper framework that can fulfill and suit the needs of Down Syndrome children in learning mathematics effectively. Based on (Abdelhameed & Porter, 2001), some Down Syndrome children does not really understand what have been taught in class due to limited theory to teach mathematics for them. Some teachers did not realize that they are using unsuitable methods of teaching which does not fit with their DS students' style of learning especially in tackling basic numbers.

The second problem indicates that the development of mobile application for children with Down Syndrome is slow. For the time being, there are only several mobile

applications for Down Syndrome in Google Play such as apps for parents guidance, manual and information about Down Syndrome, and importance of physiotherapy. But among all, there is no apps specialized on educational purposes for DS children. Furthermore, study by Ortega-Tudela & Gómez-Ariza (2006) found that Down Syndrome children learn faster in basic counting when they have been taught using multimedia approach rather than using paper and pencil. Unfortunately, nowadays, most of the learning applications, games and Web sites were designed without considering the special needs of DS people (Feng & Lazar, 2010). Thus, the scope of this project development has been specified on numerical skills of mobile application mainly for DS children who have moderate level of IQ.

1.3 Objectives of study

To address the problem statements stated before, among the related objectives of the project are:

1) To identify suitable learning theory(s) to be used in developing numeracy conceptual framework for Down Syndrome children
2) To develop a mobile application on learning the basic of numbers for Down Syndrome children
3) To evaluate the user acceptance on the developed mobile application

Research was conducted in order to identify the suitable learning theory(s) that can be applied in developing numeracy conceptual framework for Down Syndrome children. The study included the analysis of existing learning theories, behavior and characteristics of DS people, area of lacking in numerical skills learning method and new approach to teach them mathematics.

Besides that, a mobile application will be developed on learning basic numbers especially for DS children. The user interface was designed at the first place based on the gathered information about Down Syndrome with the guidance from Supervisor and

other lecturers. The suitable learning theories with concept of TouchPoints were introduced and applied in this mobile application project. Colorful screen with attractive picture is one of the focuses to catch DS children's attention in understanding basic numerical knowledge. Other focus would be the content of the application which is repetitive concept in learning numbers because DS children experienced cognitive delays that slow down their learning process.

Last but not least, user acceptance test will be conducted at the end phase of the project development to satisfy the needs of the target users. A group of Down Syndrome children with different level of IQ will be using the mobile application for learning and testing purposes. Feedback from their teachers and parents will be gathered and analyzed for future improvements.

1.4 Relevancy of the project

The study is focusing on the Down Syndrome children with moderate level of IQ who are learning to recognize basic numbers. Number Skills Mobile Application project will be very beneficial and relevant to the targeted end-users because they faced difficulties in learning mathematics. It is a personalized educational application specifically designed for them that will suit their learning ability. By using this application, they can learn basic numbers in an effective way with several learning concepts included such as the repetitive method, number 'TouchPoint' and fun interactive activities for each basic numbers. As DS children can loss their focus easily, such this interactive learning is essential to them because it can retain their focus longer.

Some teachers used unsuitable methods in teaching mathematics to DS children. It resulted in frustration for both teachers and students because the students cannot capture what has been taught by the teachers. With the development of this project, it will be useful for DS teachers because it is a new way that can assist them to teach their students in learning basic numbers with the right and interesting method.

1.5 Project Feasibility

Within eight months starting from May to December 2013, this project has been completed at least to the minimum requirements because the real users will be using it in their learning process. The first four months was allocated for the designation of the proposal, conceptual framework, system architecture, idea gathering as well as preliminary results and findings on literature review, interview and prototype designation. The development of the mobile application and testing were done on the second period starting from September to December which was in Final Year Project (FYP) 2 time frame. It also depends on the amount of scope creep and testing results that were encountered which was inevitable. Due to that, it is difficult to gauge how perfect the system can be within the time frame, but the best effort will be given in ensuring a good product will be produced for the DS children.

CHAPTER 2

LITERATURE REVIEW

2.1 Health

According to Ratson (2003), health is defined as "a state of optimal physical, mental, and social well-being, not merely the absence of disease." Health also can be said as the absence of certain qualities such as disease or body abnormality, and it related with no feeling of anxiety, pain, or distress that may or may not accompany disease (Aggleton, 2000). Nowadays, not only adults are suffering from health problems, but children also affected with various diseases by many factors around them.

2.1.1 Children and Diseases

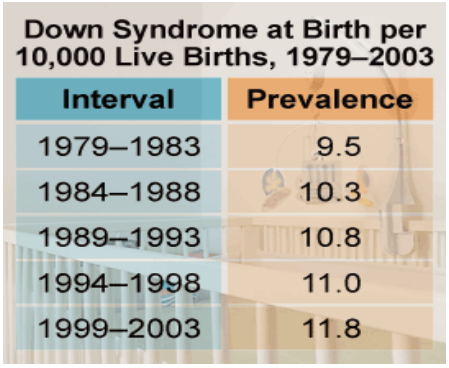
Aggleton (2000) mentioned in his book that disease is the presence of some pathology or abnormality in a part of the body. For children, they are exposed to a lot of diseases since they are born such as Jaundice, Tuberculosis, Scurvy, Rickets, Rubella, Asthma, fever, flu and many more (Raue, 2000). Lorenz (2001) stated that one of the most frequently occurring chromosomal abnormalities that happens before birth is called Down Syndrome. It is a genetic condition, caused by a failure in the cell division process.

2.2 Understanding Down Syndrome

2.2.1 Down Syndrome

Down Syndrome (DS) is the most common cause of genetic mental retardation and it is also the main factor of specific birth defects that usually delays the physical and mental growth of the babies Sherman et al. (2007). Cohen, Nadel and Madnick (2002) stated that Down syndrome is also associated with a wide variety of other clinical features, including congenital heart and intestinal disease, eye problems, deficits of the immune and endocrine systems, and increased risks for leukemia and Alzheimer disease, as well as characteristic facial and physical features. Down syndrome is named after the British physician, John Langdon Down, who described the syndrome in 1866, and in 1959, the condition was identified as a chromosome 21 Trisomy (Lorenz, 2001).

Figure 2.1 is the statistic on that the number of Down Syndrome children born in the world is increasing from the year 1979 until 2003. The prevalence is getting higher and it proves that the Down Syndrome rate of birth is rising from year to year. In Malaysia, the occurrence of Down syndrome is one per 950 births. This is according to Universiti Sains Malaysia's (USM) Human Genome Center and Genetic Clinic which also mentioned that the breakdown are, one in 981 Malays, 940 Chinese and 860 Indians have Down syndrome, and this information is based on 1989 records (Ibrahim, 2013).



Down Syndrome at Birth per 10,000 Live Births, 1979–2003

Interval	Prevalence
1979–1983	9.5
1984–1988	10.3
1989–1993	10.8
1994–1998	11.0
1999–2003	11.8

Figure 2.1. Prevalence of Down Syndrome

Source: http://www.cdc.gov/features/dsdownsyndrome/

2.2.2 Causes of Down Syndrome

Crosta (2009) pointed out that Down Syndrome is caused by an error in cell division that results in an extra 21st chromosome. Down syndrome occurs because on the part of 21st chromosome, there is an abnormality characterized by an extra copy of genetic material. Normally, in each cell, there are 46 chromosomes. 23 were inherited from the father and mother each. Down Syndrome will happen when some or all of a person's cells have an extra full or partial copy of chromosome 21. There are three types of Down Syndrome known as Trisomy 21, Mosaicism and Translocation. Trisomy 21 is the most common type of Down Syndrome affected to 95% of those DS people. It is a condition where a person has 47 chromosomes in each cell instead of 46 caused by an error in cell division which leaves a sperm or egg cell with an extra copy of chromosome 21 before or at conception. This situation is called 'non-disjunction'.

Another 5% of Down Syndrome cases are because of Mosaicism and Translocation. Mosaicism is a condition where cells contain mixed numbers of chromosomes. Some have 46 and some have 47 chromosomes. For Translocation, Down Sydrome develops when the abnormal chromosome 21 translocates or change location. A person with a Translocation may have a greater risk of producing a child with an extra 21st chromosome even they may looks physically normal (Brill, 2007).

The only factor that contributes to the probability of having Down Syndrome baby is maternal age. For mothers who are ages less than 30 years old, the ratio is one per 1000 pregnancies, while for mothers who are 44 years of age and above, there are about 1 in 35 pregnancies results in a baby with Down Syndrome. Risk of having a baby with Down Syndrome is higher if the mother age 40 and older, if the mother have Down Syndrome siblings and it is also risky if she has another baby with Down Syndrome (Crosta, 2009).

2.2.3 Characteristics of Down Syndrome Children

Based on Selikowitz (2008), the condition of Down Syndrome children can be recognized at or shortly after birth. In common cases, the doctor will be quite sure of the diagnosis based on the appearance or characteristics of the child. But in some cases, doctors may suspect that the child has Down Syndrome, but will need to wait for the result of a chromosome test before being certain. For the physical characteristics, Evans-Martin, F. F. (2009) mentioned that Down Syndrome children have some specific features caused by the extra chromosomes. They usually have low muscle tone and poor reflexes. Compared to normal people, their joints are looser, their skull is short, broad and slightly smaller, and the back of their head is flatter. Newborns with DS often have extra skin on the back of the neck, and when they get older their neck will appear short and wider than usual. For the facial shape, it is round when they are born and becomes oval as the child ages. Due to underdevelopment, the middle of the face looks flat, the nose and nasal openings are small, and the nasal bridge is flatter than normal. Their cheeks are also round and the mouth may be small and have turned down corners.

As shown in Figure 2.2, the tongue is protruding due to low muscle tone and small oral cavity. Besides that, their teeth may be small and usually unshaped as it develops late and in an unusual order. For the specification of their eyes, the palpebral fissures, or the opening of the eyes are smaller than normal and slanted upward. Small white sports on the iris are called brushfield spots and small folds of skin that cover the inner corners of the eyes are called epicanthal folds. The ears of DS children tend to be small, slightly lower on the head, cupped shape or the upper part may fold over that producing a square shape. They also can suffer from loss of hearing sense if not treated because of their smaller ear passages which caused it to be more easily blocked. In general population, individuals with Down Syndrome are likely shorter and stockier than normal people. Their hand are wide and short, with shorter finger. The fifth finger may curve inward and have one crease instead of two. Some may have one deep palmar crease, a crease across the palm, instead of the common two. Lastly, the Down Syndrome children have

wide and short feet often with a gap between the first two toes, and if the gap is present, a plantar crease will extend from the gap (Evans-Martin, 2009).

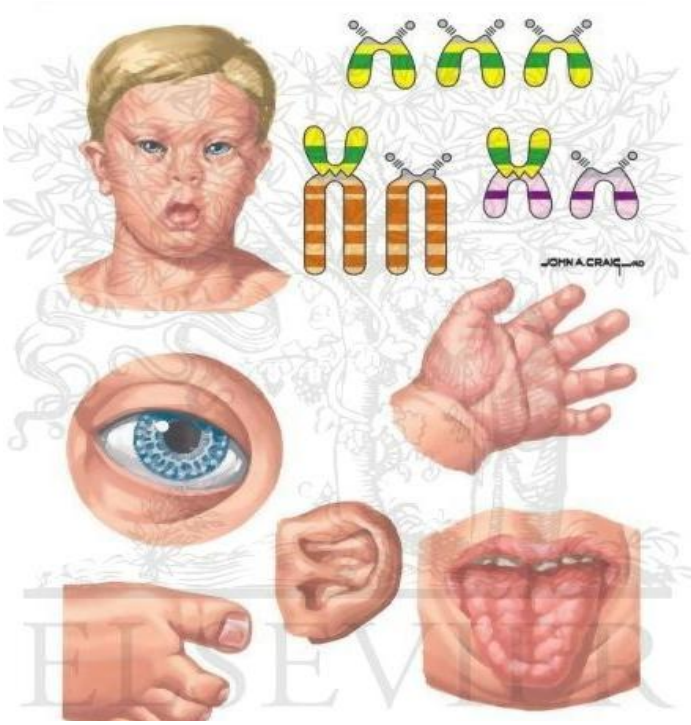


Figure 2.2: Characteristics of the Down Syndrome Children
Source: http://specialededuc3026.wikispaces.com/

According to Jarrold & Baddeley (2001), children with Down Syndrome's speech is not clear and can be difficult to understand which can result in language delay. This is because they have small and narrow upper jaw, and a high palatal arch. It also affects their usage of mouth including eating, cup drinking, chewing and swallowing solid foods. Moreover, DS children also have problems of working memory functions and limited use of strategies for memorization which causes difficulty in learning and short attention span.

2.3 Learning

2.3.1 Learning Disabilities of Down Syndrome Children

Kemp, Smith, & Segal, (2013) stated that, learning disabilities or learning disorders is a term for a wide variety of learning problems. Children with learning disabilities are not lazy or dumb and it is not a problem with intelligence or motivation. Their brain is affected on how they receive and process information. They have difficulties in analyzing basic knowledge and the most common types of learning disabilities involve problems with reading, writing, math, reasoning, listening, and speaking.

For Down syndrome children, they also faced the problem of learning disabilities which they need customized learning methods that can suit their learning style. Some of the things that can be seen from them are, they have slow responses to instructions, can't read and write, don't know how to calculate, can't speak and hear well, easy to get bored with the same activity, difficult to concentrate while learning and many more (Nasir, 2004). Children with Down Syndrome have a wide diversity in term of personality, intelligence, learning style and attitude. They need to get the same attention and inclusion in the community as well as the education which are needed to develop their social skills and academic knowledge. But different types of specialized style of learning, therapies, counseling, and training must be provided to them in order to help and suits them to learn better.

2.3.2 Learning Theories

Learning theories is explained as how an individual accept, obtain, process and retain information or inputs while learning. It is very helpful for teachers or educators as they can apply suitable teaching methods to the students. This is an advantage because they are able to know how knowledge is acquired as their learning process (Alzaghoul, 2011). There are several types of learning theories such as constructive, cognitive and behavior. Based on the research, the most suitable learning style for Down Syndrome children is

cognitive and constructive learning theories. To come out with the best numerical concept mobile application for them, all the theories will be included in the product later.

2.3.3 Constructive Learning Theory

Constructive learning theory or “Constructivism” is emphasizing on the importance of the active involvement of students in constructing knowledge for themselves, and building new ideas or concepts based upon current knowledge and past experience. Among the base teaching and learning on constructivism are discovery, hands-on, experiential, collaborative, project-based, and task-based learning (Hein, 2000) (Hein, 2000). Relating to the scope of this project, constructivism in mathematics is an essential learning method for students. Schwingendorf (2004) mentioned in his studies that students need to construct their own understanding of each mathematical concept, because the main role of teaching is not to lecture, explain, or otherwise trying to "transfer" mathematical knowledge, but actually it is to create situations for students that will foster them in making the necessary mental constructions. Moreover, a critical aspect of the approach is the breakdown of each mathematical concept into developmental steps.

According to (Steele, 2005), based on constructive learning theory, key ideas that can be applied in teaching special children are, relate lessons to real life situations to make ideas more meaningful, design activities that need students to actively participating, and provide clear explanations as well as guidance to ease the process of learning. These ideas can be converted and applied in the designation of the mobile application later which would be useful for the Down Syndrome children.

2.3.4 Behavior Learning Theory

Behavior learning theory or "Behaviorism" is based on the idea that all behaviors gained through conditioning which occurs because of interaction with the environment. For acquisition of knowledge, behaviorism learner is dependent upon an instructor or teacher. The instructor must demonstrate factual knowledge, then observe, measure, and modify behavioral changes in specified direction. Through stimulation of senses, the correct response will be achieved from the students (Cherry, 2011).

Several key ideas on behavioral theory are; firstly, break down a task into small segments. This is to make the process of executing it easier. Then, model, demonstrate and explain each step of a procedure. Include as much as practice and activities that related to the task. Lastly, monitor and collect feedback as lesson continuous (Steele, 2005). These key ideas of behaviorism are suitable to be included in the numerical concept that will be designed for the DS children in order to assist them to understand numbers in an effective way.

2.3.5 Cognitive Learning Theory

In understanding the learning process of people with Down syndrome, Cognitive learning theory took place when the surrounding information is converted into useful knowledge that is stored in the long-term memory, or in other word, they learn through experiences (Hammond et al. 2001). Based on ("What is Down Syndrome", 2012), usually Down syndrome is related with some impairment of cognitive ability that they tend to have a cognitive ability lower than average rate, often ranging from mild to moderate disabilities. Bruno et al. (2003) found that Down syndrome children preferred direct manipulation learning method especially in any animations, objects, images and colors. They also favored a simpler format of verbal content for them to understand better. In addition, most of Down syndrome children who perform better in school are

who have received family support and encouragement, enhancement therapies and early involvement programs.

As for the teaching methodologies for Down syndrome children, (Ibrahim Z. , 2012) stated that the 'learning through play' concept is proven to be effective where the concept of play is used as a stimulating environment. The teachers as well as parents have to continuously planning for various meaningful, fun and attractive activities for their children to keep their interest going. Besides, the other method is learning in group and individual sessions. Those DS children have to be encouraged to actively participating and exploring while learning. For the group sessions, the children get to learn to take turns and they are able to mingle around and communicate with their teacher and friends. The individual session is conducted one-to-one based on each child's education plan. The emphasis is to be positioned in assisting the children to attain the goals and objectives in learning through suitable teaching methods. The focus of this project is on numerical skills of Down Syndrome children and more topics will be discussed more throughout the Literature Review.

2.3.6 Numerical Conceptual Framework for Down Syndrome Children

Down syndrome (DS) children seem to have more difficulties in learning number skills compared to reading skills. They need personalized learning in numbers due to their slower learning pace. To perform mathematical calculations, cognitive skills such as the ability to represent, store and retrieve information for long term memory can be used. But, for some who have poor skills in that area, it will result in slow and often inaccurate recall of number facts. Besides that, the lack of skills in procedural knowledge and executive functions may result in incorrect selection and use of mathematic algorithm. Dunaway (2010) stated that, DS children are lacking in cognitive areas because the ability to obtain numerical skills are poor compared to their functioning in other areas.

A few researchers have conducted a research to study about to what extent computer-assisted teaching facilitates effects the learning of basic mathematical concepts and skills in children with Down Syndrome compared to traditional way of teaching which only used papers and pens. The result of the research was DS children who learned mathematics using multimedia showed a better performance compared to other group (Ortega-Tudela and Gómez-Ariza 2006).

"Teaching Mathematics to Children with Down Syndrome" is one of the significant researches that have been done. The scope of the study was to design a learning tool for teaching basic mathematics concepts, such as addition operation to the DS children. Some important features of the software to teach those children are avoid using excessive textual interface of instructions and more focus on pictures and animations. Other than that, verbal content must be presented in the simpler format so the DS children can adapt to it easily and can learn in an enjoyable way (Bruno et al. 2003). The research shows that by using technological advances such as computer application and mobile devices, children with DS can increase their cognitive ability in learning mathematics effectively.

To strengthen the conceptual framework, constructive and behavioral learning theory also will be added such as in key ideas of constructive learning theory, the lessons must be related to real life situations to make ideas more meaningful and constructive (Steele, 2005). So, the elements that will be inserted in the mobile application is mainly about calculating objects and things that always been used by DS children in their daily life to construct their ideas based on their daily experiences. Besides that, activities that will be designed need the students to actively participating, and clear explanations as well as guidance must be provided to ease the process of learning. In this context, games and numbering activities will be designed to attract students to continuously participating and an example of action also should be included to show the children what need to be done. This is related with behaviorism theory which modeling, demonstrating and explaining each step of a procedure need to be provided in their learning tasks. These

ideas can be converted and applied in the designation of the mobile application later which would be useful for the Down Syndrome children to understand better.

2.4 Technology

2.4.1 Personal Computer (PC)

Technology is defined as an application of scientific knowledge for practical purposes especially to industry (Saurabh, 2010). Personal computer (PC) is one kind of technologies that rapidly evolve from time to time. Computer can be described as an object that can accept inputs and produce outputs. The term of computer also is said to describe an electronic device containing a microprocessor, which is a small electronic device that can carry out complex calculations in the blink of an eye (Tyson & Crawford, 2011). In education field, the technology of PC is expanded into the development of courseware.

2.4.2 Courseware

As mentioned by (Jing, 2005), courseware is educational material intended as a kits for teachers, trainers or as tutorials for students, normally packaged for use with a computer. The content for teachers and trainers may include set-up information, a course plan, teaching notes, and exercise. It can encompass any area of knowledge, especially subjects that are related with Information Technology. Courseware can include material for instructor-led classes, material for self-directed computer based training (CBT), Web sites that offer interactive tutorials, material that is coordinated with distance learning and videos for use individually or part of classes. The most common means of delivering courseware that is not offered online is the CD-ROM. The style of learning is currently changing from courseware to mobile application. It is much attractive and more interactive for students to learn educational subjects instead of traditional way that sometimes can be too stressful for the students especially those with Down Syndrome.

2.4.3 Mobile Application

According to Janssen (2012), mobile application is most frequently referred as an app. It is a kind of application software designed to run on a mobile device such as smart phones, tablets or any touch screen devices. Mobile applications commonly provide users with similar and simpler services to those accessed on computer. They are normally small, light with limited and isolated functionality such as game, calculator, mobile Web browsing and others located on various types of mobile software platforms.

2.4.3.1 Mobile Operating System (Android)

Operating System (OS) that operates a smart phone, tablet and other digital mobile device is called as mobile operating system. It is a set of data or programs that manages all hardware and optimizes the efficacy of the application software in the device. Mobile operating system can be seen in smart phones powered by Android, iOS, BlackBerry OS, Windows Mobile, Palm WebOS, Symbian, Maemo and many more (Viswanathan, 2012). As mentioned by (Karch, 2012), the world's most widely used operating system for touch screen smart phones is Android. Android is an open source Linux-based mobile OS developed by Google. It is software of choice because it is low-cost, customizable, light weight OS for high technology devices without developing one from scratch. This can be proved by Figure 2.3 below. It shows the bar chart that indicates the use of Android is the highest compared to other software platforms for developers in the first and third quarter of 2013. While Figure 2.4 stated that, in Malaysia, the most common used mobile software platform is Android followed by Symbian, iOS, BlackBerry and Windows.

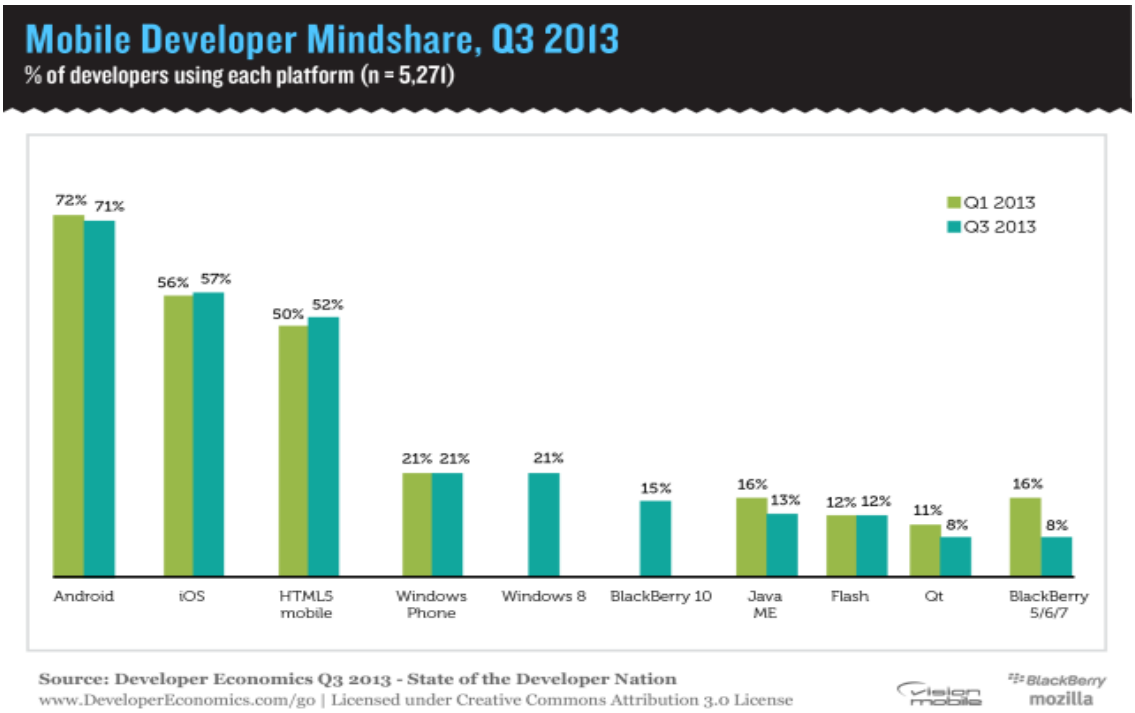


Figure 2.3: Percentage of Developers using Different Platform
Source: http://www.developereconomics.com/report/q3-2013-state-of-mobile-developer-mindshare/

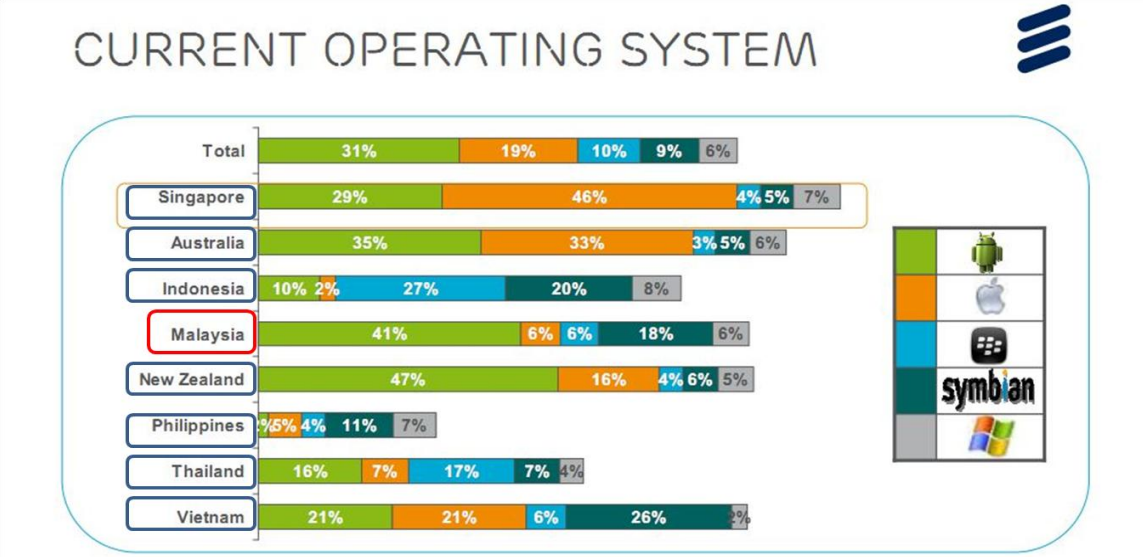


Figure 2.4: Current Operating System in Different Countries
Source: http://amanz.my/2012/09/android-dan-symbian-lebih-popular-berbanding-blackberry-ios-dan-windows-phone-di-malaysia/

2.4.3.1 Mobile Application Learning Approach on Number Skills

As an approach to teach Down syndrome children in mathematics, mobile application is an effective way to attract their attention to learn and understand better. Besides, this way of learning can keep their interest going while learning mathematics because the Cognitive learning is presented by repetitive and interactive methods which need them to touch the screen of the device and learn numerical skills in different way. The concept of touch, feel, follow and learn will be applied in this mobile application project based on Android software platform. Other than that, the colorful screen with attractive animation is a good combination to catch DS children's attention and construct them in understands basic numerical knowledge. The interface and function description of the product will be shown in the Result section.

2.4.4 Comparison Study of Existing Products Developed for Down Syndrome

Several comparisons have been observed from the market on the products and mobile applications developed for Down Syndrome people. The first product is called Numicon. Numicon is a multi-sensory maths teaching program using Numicon maths shapes in a series of practical teaching activities. By combining and comparing shapes to do arithmetic in a series of practical activities, learners develop their own mental imagery because Numicon's visual, auditory and kinesthetic approach appeals to different learning styles. Students learn through both seeing and feeling how Numicon patterns connect with each other. Students will experience with both their hands and their eyes how numbers fit together by physically manipulating Numicon to build constructions, make arrangements and patterns and play games using the feely bag (Numicon, 2013). As shown in Figure 2.5, the drawback of this method is it cannot retain the DS children attention span longer than multimedia learning devices because the tools are static and not interactive.

Figure 2.5: Numicon Tools
Source:
https://global.oup.com/education/content/primary/series/numicon/?region=international

Other than Numicon, TouchMath is also a multisensory program that uses TouchPoints to differentiate each basic numbers from zero to nine. Based on Figure 2.6, numerals one through five have single TouchPoints and six through nine have double TouchPoints. Students will associate numerals with real values as they count the touch points. For example, in Figure 2.7, two TouchPoints indicates two elephants and it is not just a squiggle on a page (TouchMath: How It Works, 2000). The weakness of this program is it not independent enough where the assistance of teacher or parents is still needed in explaining the concept to DS children. But, TouchMath is a good concept to be applied in the designation of this mobile application project because sound instructions will be provided to DS children even when they are using the application alone. Furthermore, they also can touch and feel the points through vibration at the devices. It can make the process of learning more fun and effective.

Figure 2.6: TouchMath Concept
Source: http://www.touchmath.com/index.cfm?fuseaction=uppergrades.welcome

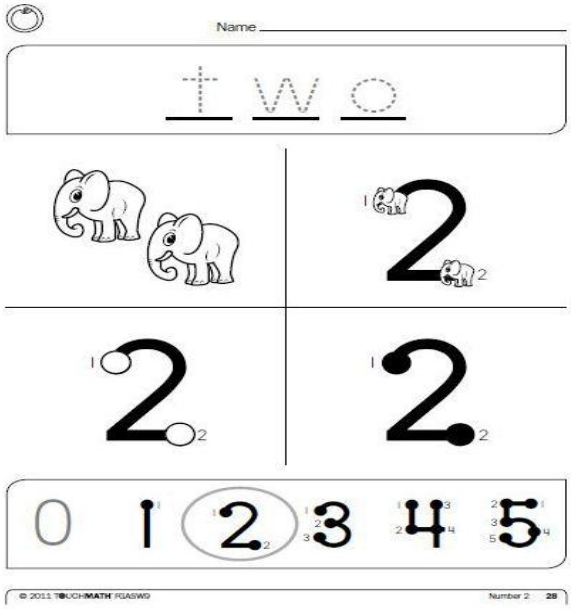


Figure 2.7: TouchMath Activities
Source: http://www.brighthubeducation.com/teaching-elementary-school/56877-using-touch-math-to-teach-addition-to-struggling-students/

Google Play is a well-known platform for downloading Android based mobile applications. Based on the key word search in Google Play for Down Syndrome application, there is no result found for educational or learning apps for Down Syndrome people up to this time of study. There are only several general applications designed for them such as apps for parent's guidance, manual and information about Down Syndrome, and importance of physiotherapy. This indicates that the development of mobile application for children with Down Syndrome is very slow. Below are a few Down Syndrome application that has been developed in the market. The first one is as in Figure 2.8. There are the screen shots of Down Syndrome Children Application. This application is not an educational application. It is only created specifically to help parents and care providers of children with Down Syndrome with the aim of not just to provide guidance, but to help the parents and care providers of Down Syndrome children see the possibilities in these special children.

Figure 2.8: The Down Syndrome Children Apps
Source: https://play.google.com/store/apps/details?id=com.yvonneyap.dsapp

Referring to Figure 2.9, the mobile application is named Down Syndrome Manual. This application was developed to provide information about Down Syndrome such as the description of the disability, the causes of it, the characteristics of DS people and others. Again, it is just a manual for users and not specifically designed for the individual for Down Syndrome.

Figure 2.9: Down Syndrome Manual
Source: https://play.google.com/store/apps/details?id=com.yogi.yogidownsyndromey1

Down Syndrome Physiotherapy is one of the mobile applications existed in Google Play as shown in Figure 2.10. This application tells the users about the importance of physiotherapy for DS children. It includes the problems that can be helped by physiotherapy and provide information on the benefits of it to the users. The disadvantage of this application is it does not relate to educational purpose and this proves that there is a need for this project of mobile application for DS children to be developed in enhancing the quality of DS children's education.

Figure 2.10: Down Syndrome Physiotheraphy

Source:
https://play.google.com/store/apps/details?id=com.yogidownsyndromephysiotherap**h**y

As some DS children also experienced Dyscalculia, a study on it also has been done. It is a math-based learning disability, which results in your child having trouble recognizing numbers and symbols and understanding basic math concepts. Common signs of this disability are difficulty recalling number sequences and understanding time, may mistake numbers that look similar in shape for example 3 and 8, cannot retain patterns when adding, subtracting, multiplying, or dividing and lastly, Dyscalculia people have difficulty with handling money or estimating cost (Callaway, 2013).

Among educational materials that have been developed for Dyscalculia students are Animal Counting Chart and 10 Sided Dice in Dice. In Figure 2.11, Animal Counting Chart is a fun and colorful felt chart featuring 10 different animals to attract any young child to play and count, while the dice game provide help for those students in learning basic numbers from one to ten. But the weakness of those products is it cannot retain the student's attention for a long time because the chart and the dice are static and not interactive. Only one mobile application has been developed for this kind of disability named DyscalculiaServices. Figure 2.12 show that this application is actually the mobile version of the website DyscalculiaServices.com. This application enables user who are mainly parents and teachers to help their child in the process of becoming more comfortable with mathematics. The comparison study proves that there are no more

educational mobile application develops for Down Syndrome children especially in knowing basic numbers.

Figure 2.11: Dyscalculia Educational Games
Source: http://www.thechildmindingshop.co.uk/animal-counting-chart-14143-p.asp

Figure 2.12: DyscalculiaService Mobile Application
Source:
https://play.google.com/store/apps/details?id=appinventor.ai_clcjvalk.DyscalculiaServices

CHAPTER 3

METHODOLOGY

3.1 Research Method

The research method used to gather all the information about the project is by using **exploratory research.** Exploratory research is about gathering information and formalizes it to identify and define a set of question related to the project. It will be done step by step starting from identifying the problems, analyzing literature reviews, specifying purpose of research, making a hypothesis, data collection, interpreting the data, reporting and evaluating research. Other than that, the research design for this project is **qualitative.** It is a systematic subjective approach used to describe life experiences and give them meaning by gathering an in-depth understanding of human behavior and reasons that govern such behavior. In this project, several comparisons on other research have been made to collect related information about DS and their learning style. Interviews also have been done to the DS teachers, parents and lecturers in order to know the behavior of DS children that will be useful during the project design.

In designing the Number Skills Mobile Application for Down Syndrome children, Rapid Application Development (RAD) methodology have been chosen in order to achieve the objectives stated previously in the Introduction section. It is used to adapt with the agile developing processes due to the time constraint. RAD uses minimal planning in favor of rapid prototyping. The lack of extensive pre-planning generally allows the mobile application to be developed much faster, and makes it easier to change requirements. RAD has several phases such as Requirements Planning, User Design, Construction, and Cutover.

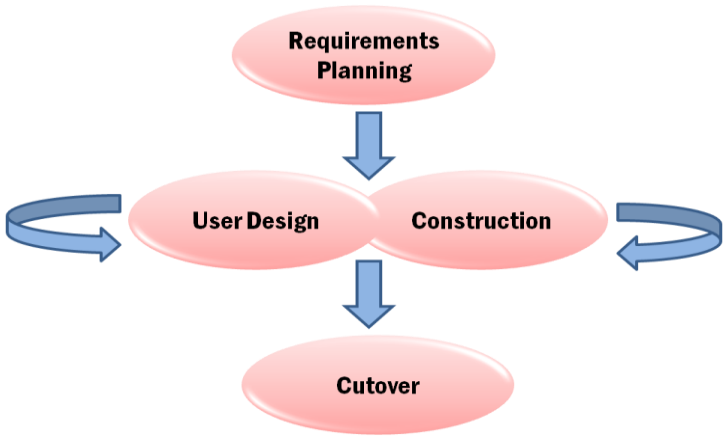


Figure 3.1: Rapid Application Development (RAD) Diagram

3.2 Project Activities

3.2.1 Requirements Planning

After the proposed title has been approved by FYP committee, the research was conducted starting with Requirements Planning. There were several requirements needed to develop this project. Firstly, based on the objectives, in order to design a conceptual framework as well as mobile application on learning basic numerical numbers for DS children, all necessary information about them, how they learn in terms of theories, the constraints and the technology involves were gathered by analyzing previous research papers, articles, literature review studies, and interviews. Interviews with a few lecturers such as Dr. Wan Fatimah, Dr. Afza Shafie and Dr. Josefina who are

involved in this project were done in order to get their opinion and suggestion on the user-interface and content of the mobile application. Interview session with DS teachers and observation on DS children's was conducted for information gathering purpose too. The results of the interview will be discussed further in Chapter 4.

To gather the requirements of the learning theories of DS children to be included in the mobile application, studies on other research have been conducted. A number of journals, articles and research papers have been read to get a big picture on it. There were several learning theories found for children with DS such as cognitive, constructive and behavioral. Those theories were combined and added with element from other studies for example TouchPoints method which was quite similar with the concept of this project. The last requirement planning was collecting data on suitable development platform and tools required to design the end product whether to use AppsInventor or Eclipse Android Development Tool (ADT). AppsInventor tool has simpler interface to develop the application but cannot provide many functions like Eclipse ADT even it is much complicated.

3.2.2 User Design

User Design is a continuous interactive process that allows users to understand, modify, and eventually approve a working model of the system that meets their needs. During this phase, the draft of suitable user-interface and system architecture like in Figure 3.2 has been designed. Feedback from Supervisor, lecturers and Down Syndrome teachers were collected in producing a successful application that can assist DS children in learning mathematics. Developer worked closely and quickly to change the unsuitable interface design and capture the application requirements as it will be the basis for the physical design later. At the end of the user design phase, the updated draft of the interface and diagrams defining the process and data interactions has been produced.

3.2.2.1 Mobile Application Architecture

In Figure 3.2 below, the system architecture can be explained starting from the user part who is the Down Syndrome children. They are the targeted end-users who will be used the application for their learning process in mathematics. The mobile application has been developed in two common languages used in Malaysia which are Malay and English language. Next, the function is divided on three parts that are Learn, Activities and Practice. For each part, there is several learning concepts inserted based on DS children learning theories which are cognitive, constructive and behavior theories. The explanations will be provided on the Results and Discussion section in Chapter 4 because it includes the screen shots of the mobile application prototype for clearer view.

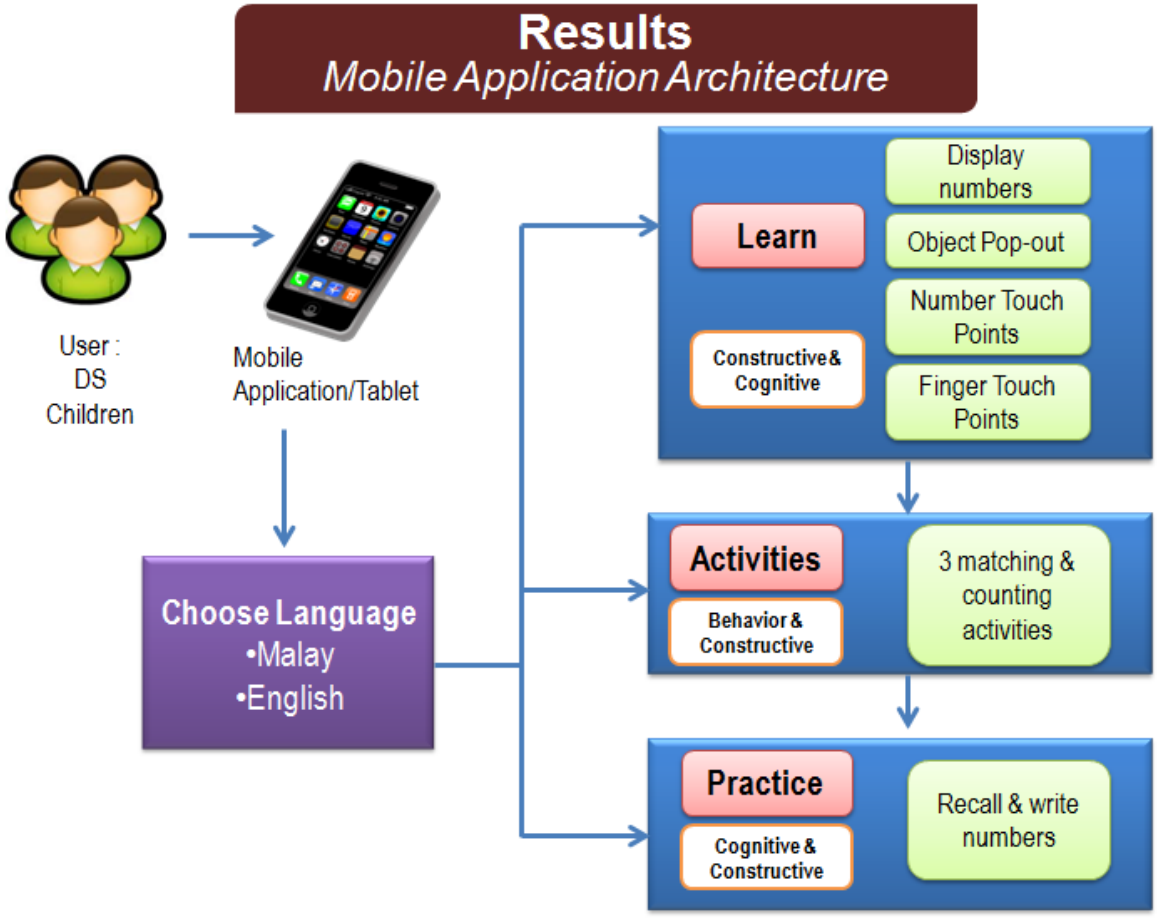


Figure 3.2: System Architecture of the Mobile Application

3.2.3 Construction

At this phase, the design of the prototype has been finalized and the development of the mobile application using selected development tool starts. Mobile Application was built using Eclipse ADT from scratch. Knowledge of programming language such as Java and XML were required during the development process. The developer applied the coding according to the preliminary interface planned at the user design phase as can be seen in Figure 3.3 and 3.4. Even though many difficulties faced in this phase, it was successfully encountered by searching guidance from Internet search of tutorial learning, programming forum and guidance from other mobile application developers. Supervisor participated in validating the screens and other aspects of the application being built. Changes and improvements can still be suggested in order to satisfy the end user in the testing phase also known as User Acceptance Test. Results of the test will be included in Results & Discussion section.

3.2.3.1 Development Tools & Equipments

- Eclipse Android Development Tool
  - Mobile application development
- Microsoft Power Point Microsoft Picture Manager
  - Designation and editing of images and pictures
- Samsung Galaxy Tab 7.0 Plus
  - Testing and demonstration of mobile application
- Indigo Studio
  - Prototype designation and flow
- Google Chrome
  - Programming tutorials, online forums and sources of sample codes

3.2.4 Cutover

Cutover is the delivery of the application to its end users. Planning for cutover must begin early in the RAD process as the product may have to be improved after some testing from real users such as Down Syndrome children, teachers and parents especially at user acceptance test. As a result, the new application is built, delivered, and placed in operation much sooner.

3.3 System Development

Based on Figure 3.3, the mobile application was developed using Eclipse Android Development Tool (ADT). Basically, there were three parts of the development tools such as XML for interfaces, Java for main functions and Android Manifest for screen connections. The interfaces have been compiled in the developer using XML language as shown in Figure 3.4.

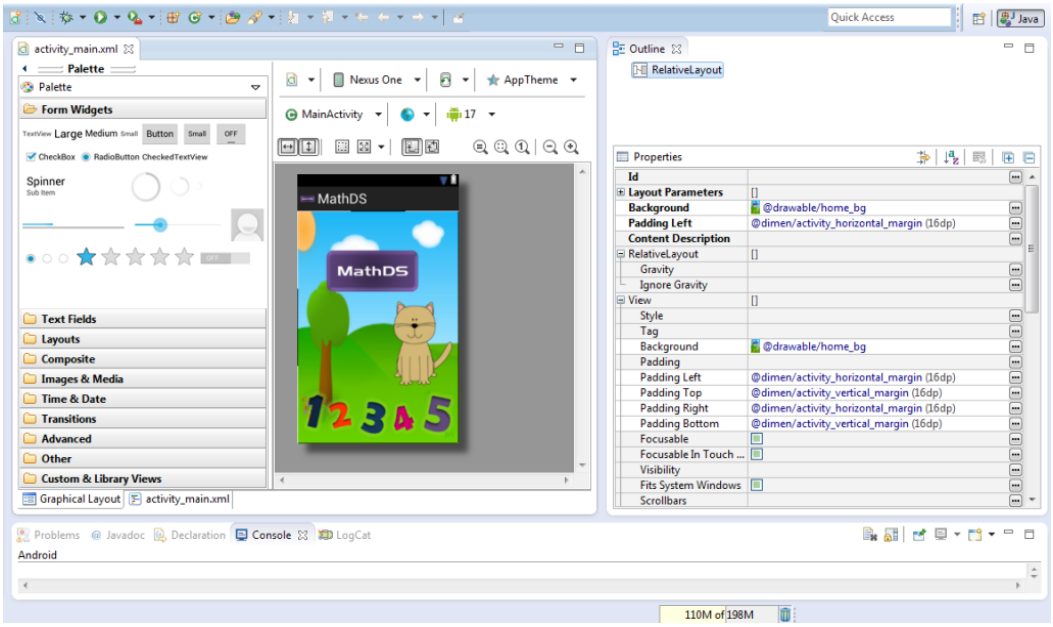


Figure 3.3 System development using Eclipse ADT

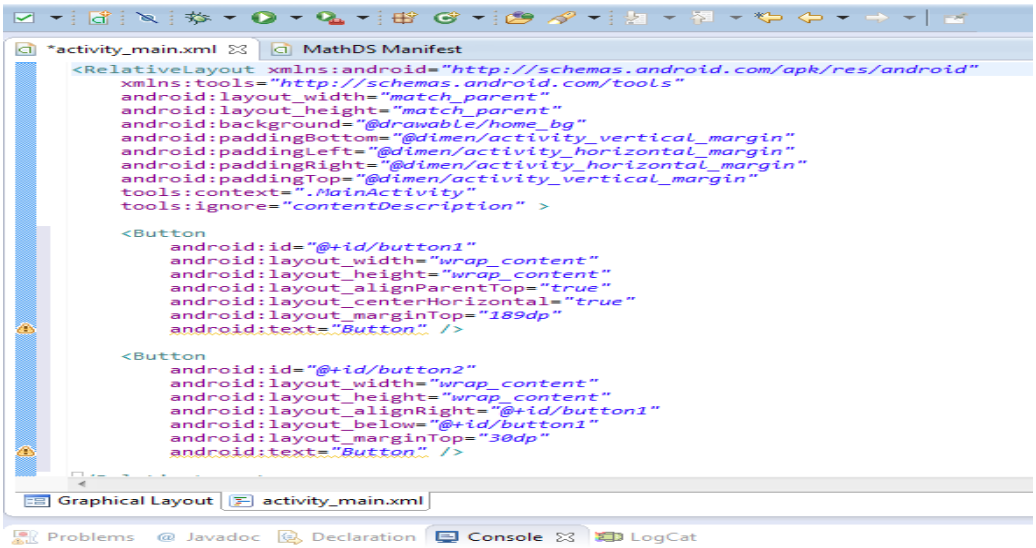


Figure 3.4 XML part for designing interfaces

To make the application function well as planned, the Java coding of the mobile application is needed like in Figure 3.5. The basic function of the buttons, screen as well as activities has been set and linked with the XML interfaces. Besides that, the connection of the screens was done in Android Manifest.xml as shown in Figure 3.6.

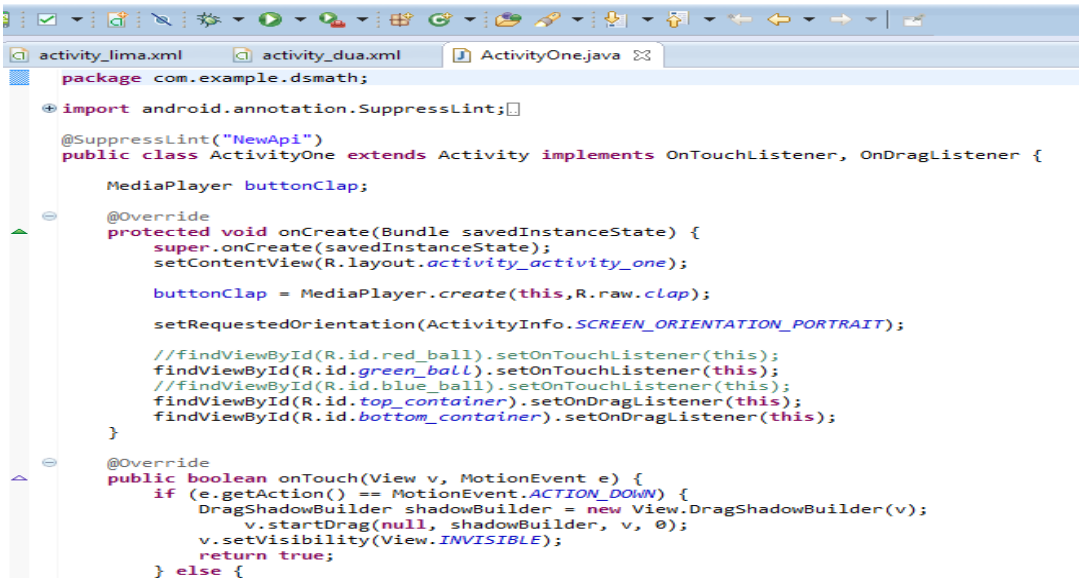


Figure 3.5 Java coding of the application

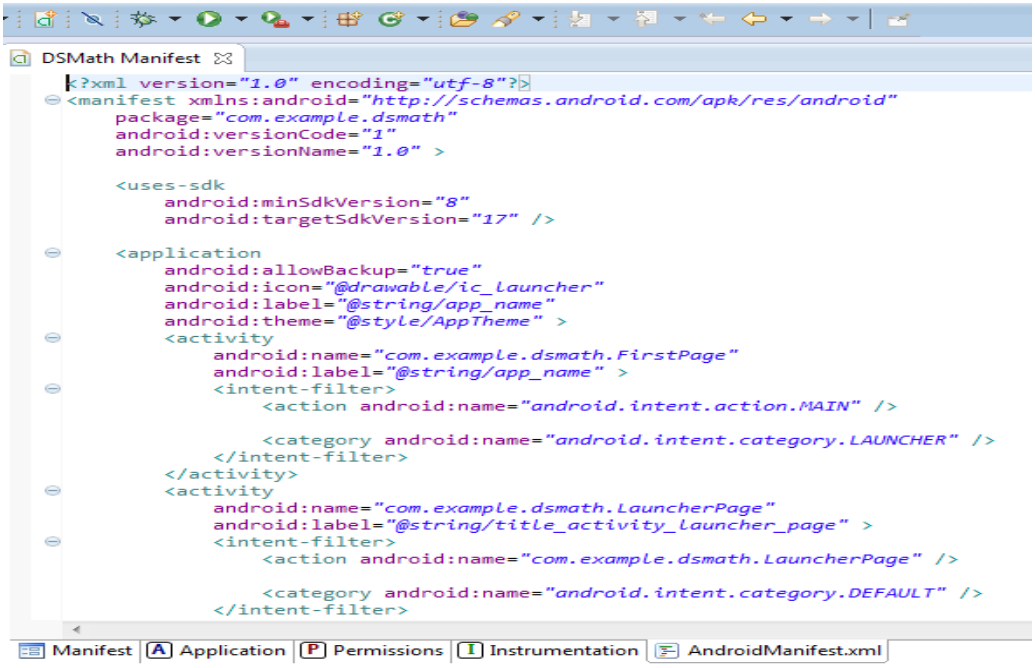


Figure 3.6 Android Manifest.xml

3.4 Key milestones

A milestone is a date estimation of the completion upon specific tasks compared with the actual completion date. It should be placed in the schedule at planning time as it is a way of knowing how the project is advancing (Esterkin, 2010). As mentioned in the project feasibility, the designation of the proposal, conceptual framework and idea gathering was allocated for the first four months, while the development of the mobile application and testing were executed on the second period that is Final Year Project (FYP) 2 time frame. Initially, the mobile application was required to be completed at least to the minimum requirement by October 2013 because there would be several changes made on the interface after the testing procedure to suit the end users. The end product which is the mobile application was completed on November 2013 to be evaluated and used by DS children for User Testing phase. This is because the development also depends on the amount of scope creep and testing results that were encountered which was inevitable. Due to that, the best effort has been given in ensuring a worthy product will be produced for the DS children even it is hard to predict how perfect the system can be within the time frame.

3.5 Study Plan and Gantt Chart

Table 1. Gantt Chart for FYP 1

Project Activities (FYP1)	Week													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Selection of Project Title														
Search for Project Title														
Planning & Requirement Gathering														
Literature review research														
Define learning styles & tools														
Submission of Extended Proposal														
Conduct interview regarding interface														
Compare existing products & technology														
User Design														
Design storyboard diagram, suitable user interface and system architecture														
Preliminary screen layout & flow of data														

Process
Suggested Milestone

Based on the Table 1 above, the Gantt chart was divided according to the elements in Rapid Application Development method. There are four main phases involved which are Planning and Requirement Gathering, User Design, System Construction and System Cutover. For the first and second phase, the activities were completed in the Final Year Project 1. The study plan started on the first week of the semester where the students need to think about the idea of their project because the submission of proposal title was on the third week. The preparation of the extended proposal such as Literature Review study and defining suitable learning styles was done part by part with the guidance from Supervisor, A.P. Dr. Wan Fatimah until the submission day on the sixth week of the semester. Literature review and research on methodology were still being continued after the submission as several contents need to be added to strengthen the research. In exploring the development platform or tools for mobile application, several weeks have

been used to identify which platform are suitable to be used such as Eclipse Android Development Tool (ADT), AppsInventor or other platform. The idea gathering like comparing existing products and interview on interface design took about three weeks to be included in the Interim Report. After that, the User Design phase took place where development of the project's interface and system architecture started because it needs to be presented during the Proposal Defense in week 12. The next activities done and completed were preliminary screen layout and flow of the application data. The last part of FYP 1 is the submission of Interim Report on week 14 and the continuation of the project will be on the next semester.

Table 2. Gantt Chart for FYP 2

Project Activities (FYP2)	Week													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
System Construction														
• Build & Develop														
Write coding														
Add functionality														
• Demonstrate														
Run simple test to show the workability														
Ensure all components interrelated and working														
• Refine														
User Acceptance Test														
Debug														
Reconstruct the application														
System Cutover														
Testing functionality and usability of mobile apps														
Check system specification aligned with requirements														
Implementation of mobile application to DS children														

Process

During the Final Year Project 2 (FYP 2) period, activities continued with the third phase of the RAD method that was System Construction. Based on Table 2 above, the process started with the mobile application development from the first week until the tenth week with many other related processes involved such as the addition of functionality, interface improvements, demonstration, user acceptance test, debugging and reconstruction. After that, System Cutover phase was done where the end-product will be delivered to DS children. Among processes involve were testing the functionality and usability, checking the system specification aligned with requirements and implementation of mobile application to DS children. The complete mobile application was expected to be done on week 14.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Literature Review Findings

From the literature review, the findings related to the problem statements and objectives are as below:

Based on problem statements:

- Some Down Syndrome children does not really understand what have been taught in class due to limited theory to teach mathematics for them (Abdelhameed & Porter, 2001).
- Usually Down syndrome is related with some impairment of cognitive ability that they tend to have a cognitive ability lower than average rate, often ranging from mild to moderate disabilities ("What is Down Syndrome", 2012).
- DS children are lacking in cognitive areas because the ability to obtain numerical skills are poor compared to their functioning in other areas (Dunaway, 2010).
- Nowadays, most of the learning applications, games and Web sites were designed without considering the special needs of DS people. So, they need personalized learning (Feng & Lazar, 2010).
- Some of the things that can be seen from them are, they have slow responses to instructions, can't read and write, don't know how to calculate, can't speak and hear well, easy to get bored with the same activity, difficult to concentrate while learning and many more (Nasir, L. H., 2004)

According to objectives:

- Key ideas on constructive learning theory that can be applied in teaching special children are, relate lessons to real life situations to make ideas more meaningful, design activities that need students to actively participating, and provide clear explanations as well as guidance to ease the process of learning (Steele, 2005).
- Behaviorism is based on the idea that all behaviors gained through conditioning which occurs because of interaction with the environment. Behaviorism learner is dependent upon an instructor or teacher for acquisition of knowledge (Cherry, 2011).
- Cognitive learning theory is the best theory to be applied as for DS people as the learning took place when the surrounding information is converted into useful knowledge that is stored in the long-term memory, or in other word, they learn through experiences (Hammond et al. 2001).
- Down Syndrome children learn faster in basic counting when they have been taught using multimedia approach rather than using paper and pencil (Ortega-Tudela & Gómez-Ariza, 2006).
- Down syndrome children who learned mathematics using multimedia showed a better performance compared to other group (Ortega-Tudela and Gómez-Ariza 2006).
- For the teaching methodologies for Down syndrome children, 'learning through play' concept is proven to be effective where the concept of play is used as a stimulating environment (Ibrahim Z. , 2012).

Other findings:

- Down syndrome children preferred direct manipulation learning method especially in any animations, objects, images and colors (Bruno et al., 2003).
- Verbal content must be presented in the simpler format so the DS children can adapt to it easily and can learn in an enjoyable way (Bruno et al. 2003).
- The world's most widely used operating system for touch screen smart phones is Android (Karch, 2012).

4.2 Interview Findings

Most of the findings through interview on the suggested user interface are almost the same with the literature review findings. Below are the additional findings gathered from the interview for the concept of interfaces:

- Bright colors of interface
- Clear sound and short yet precise instructions
- Direct manipulation of object and images
- Very simple format of content and activity
- Repetitive concept of learning
- Bigger font
- Not much object in one interface to avoid confusion
- Use simple object or animals that they know and see in daily activities for the mobile application to construct their knowledge

4.3 Prototype/ Modeling

Due to the completion of the storyboard design, the user interface had undergone preliminary development. The user interface was developed using storyboard software named Indigo Studio. The flow of the mobile application was designed using the software too. After collecting some information about Down Syndrome children, the interface were designed to be as friendly as possible specifically for their usage. Figure 4.1 below, is the Home screen for the application. The application will be called 'MathDS' or Math Down Syndrome. It was developed with two languages that are Malay and English and it has three main activities which are "Learning", "Activities" and "Practice". As Down Syndrome children faced difficulties in learning very basic numbers, so, for this application, the Supervisor requested to have only numbers one to five for the first version. The flowchart of the application is provided below in Figure 4.2 for more understanding.

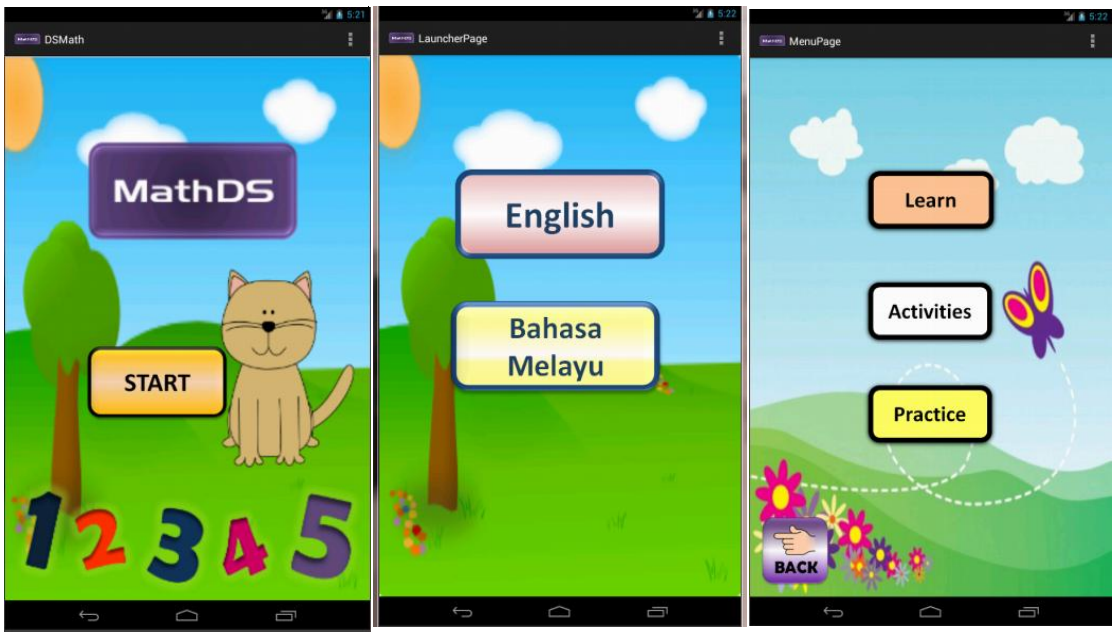


Figure 4.1: Home screen and Menu screen

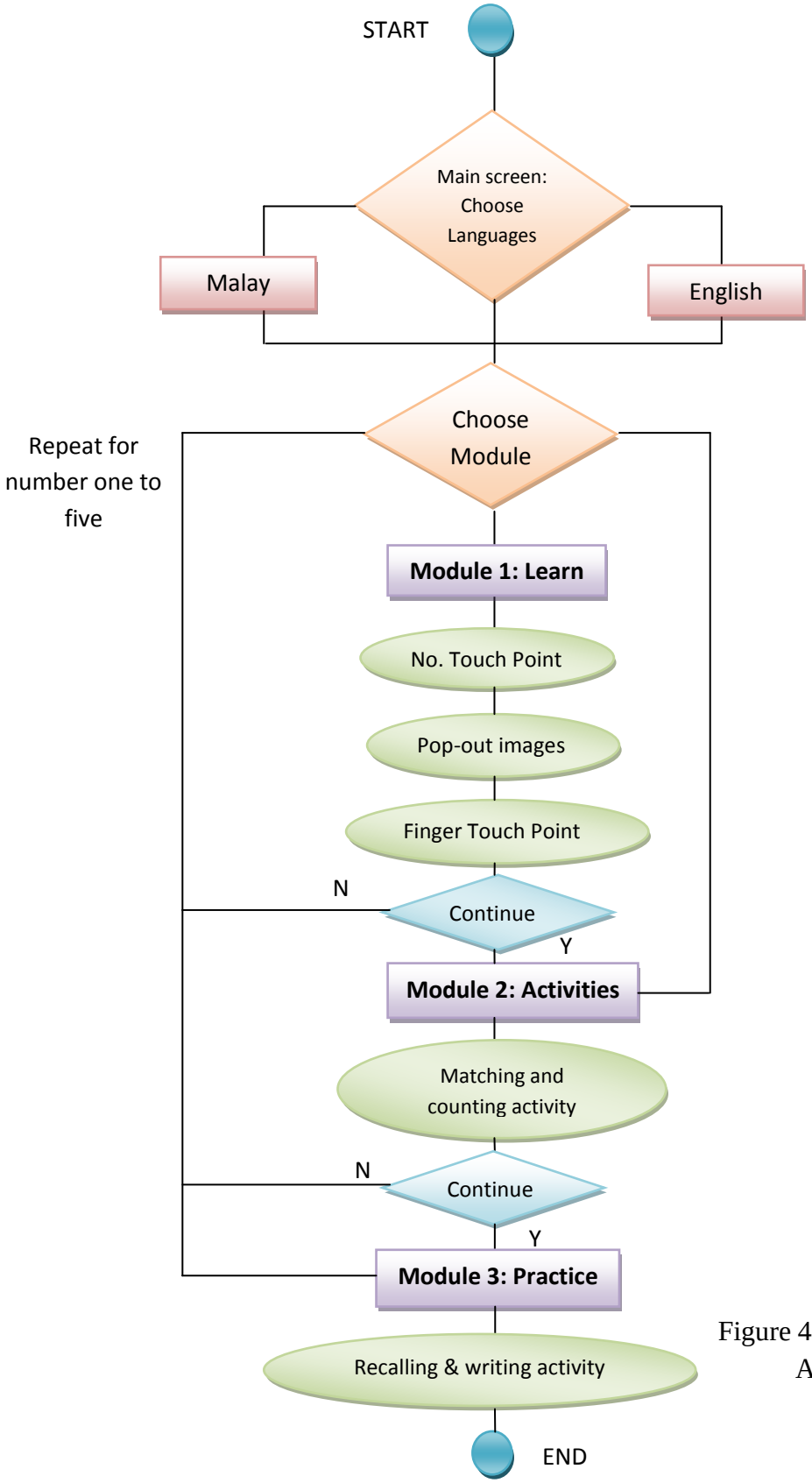


Figure 4.2: Flow Chart of Application

For “Learn” section, users will learn numbers in two different styles. It followed the concept of constructive, cognitive and behavior learning theories. Firstly, the number will be introduced to them using ‘TouchPoint’ method as in Figure 4.3. Constructive method applied when the user learning initiated by the numbers displayed and objects pop out with clear numbering sound when the yellow points were touched. The images or pictures like in Figure 4.4 indicating the cognitive concept as users can relate and know what they see on the screen based on their daily experiences. Besides that, in constructive learning theory, the activities designed for students to actively participating and applied hands on, thus, the touch concept suits the theory when the user must participate in order to learn numbers. Then, the users need to do the fingers like what have been shown in Figure 4.5 while touched the desired yellow points. This shows that behavior learning theory included in this section for counting purposes. It is good if there’s a teacher, parents or normal people assisting the DS children while using the application to strengthen the behavioral concept because the children might need guidance in learning.

Figure 4.3
Number
displayed

Figure 4.4
Images Pop Out

Figure 4.5
Finger Touch
Points

"Activities" section in Figure 4.6, 4.7 and 4.8 provides the users with simple matching activities that have been divided into three sub-activities according to the complexity level. For "Activity 1", users needed to drag and drop suitable picture with correct number. "Activity 2" also applied the concept of drag and drop but the concept is different where correct number has to be matched with the correct picture. Lastly, "Activity 3" will instruct the user to count and choose number based on the picture. Based on the research, DS children cannot experience too complex situation or activity. These sections designed using the concept of constructive and cognitive learning theory because it involved direct manipulation with animation, object and colors.

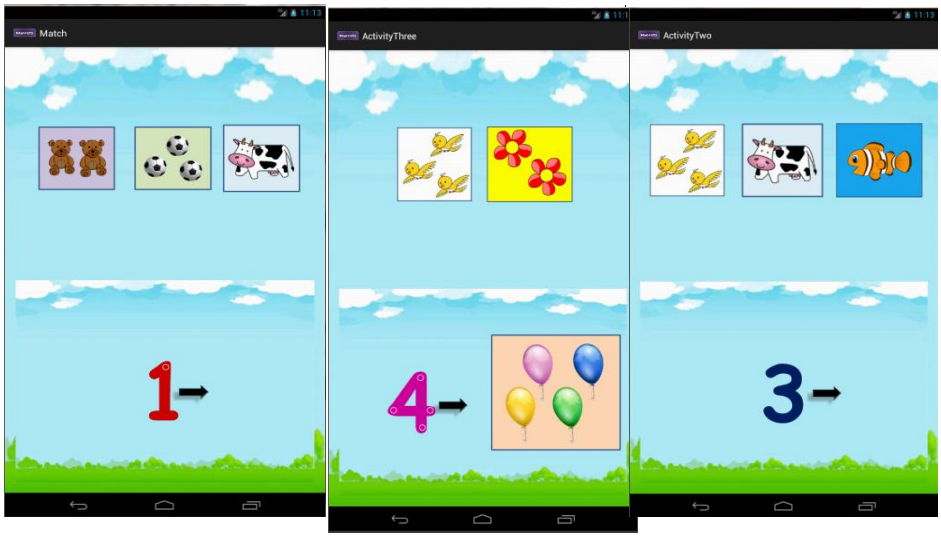


Figure 4.6: Sample of Activity 1

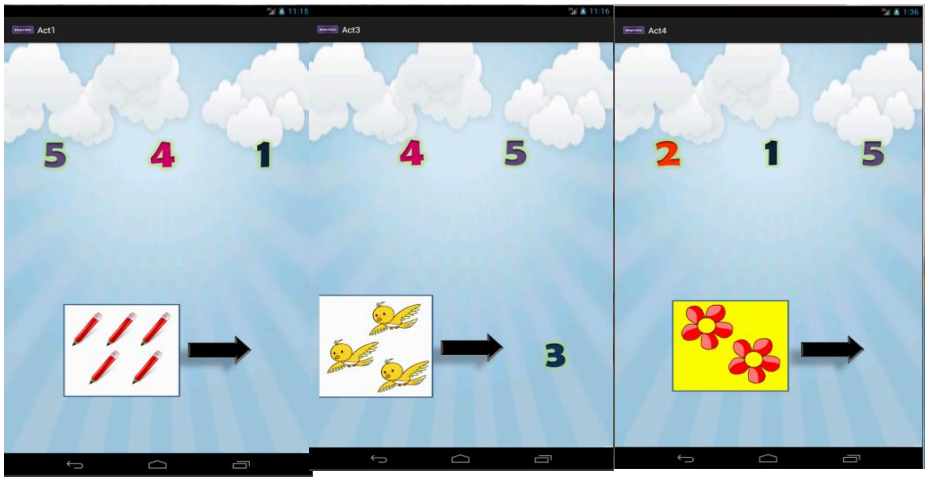


Figure 4.7: Sample of Activity 2

Figure 4.8: Sample of Activity 3

According to Figure 4.9, the last section is “Practice” which users needed to write number one to five. It was designed for the users to recall back what they already learn in “Learn” and “Activities” section. This is to test user’s ability to recognize numbers after several related activities before this section. The practice suited constructive and cognitive learning theories which stated that, practice and activities that related to the task must be included after the process of broken down the tasks into small segments.

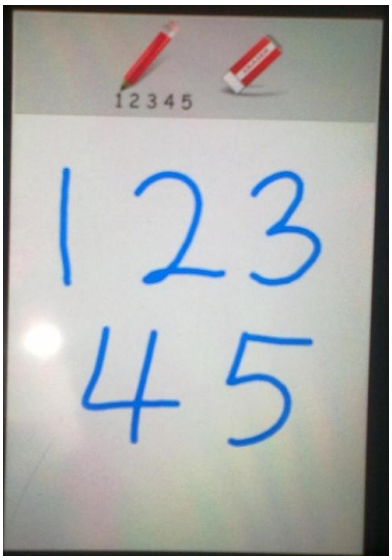


Figure 4.9: “Practice” section

4.4 System Evaluation on User Acceptance Test

For system evaluation or user testing, several respondents were asked to use the mobile application while their behavior was recorded. This was done to see their reaction and effectiveness of the application. Four of the respondents have a moderate level of IQ and the other child cannot even interact with people around him. Below are the details of respondents who have done the User Acceptance Test for the mobile application. In Figure 4.10, the first respondent is a Down Syndrome children with moderate level of IQ. His name is Ariff, 10 years old. According to the doctor, he has a minor Down Syndrome. He knows basic mathematical and reading skills as he's going to school since small.

Some observations on him while using the application are:

- He seemed so interested while using the application
- Touched the right points on the screens after being instructed once
- He can use the application well after several times repeating the learning
- Did well in "Activities" section and drag the correct answers
- Able to recall and write number 1 to 5 in "Practice" section

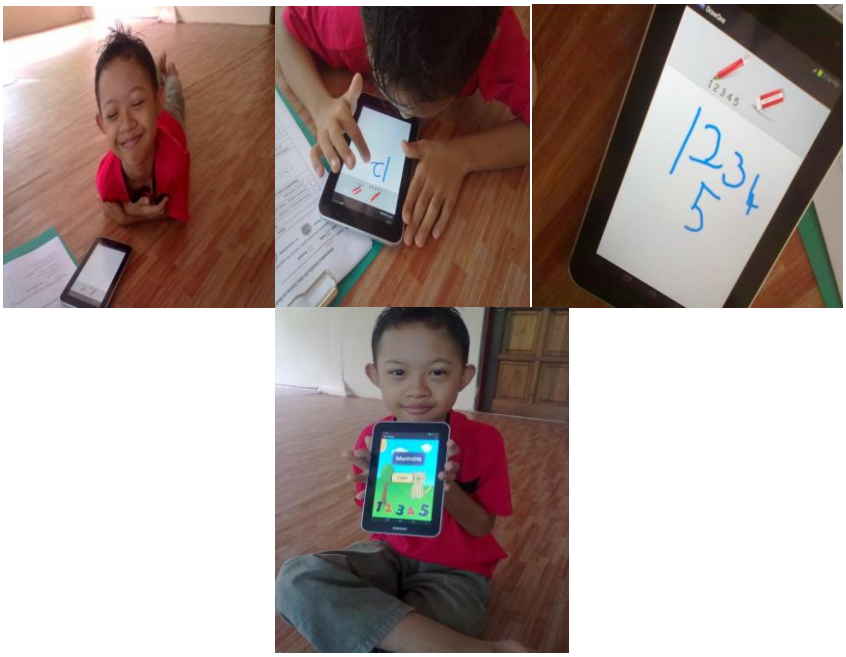


Figure 4.10: Respondent 1 (Ariff)

The second respondent is also a Down Syndrome children with moderate level of IQ named Ammar Rushdy who is 9 years old as shown in Figure 4.11. Even though he can't speak clearly, he is a brilliant kid who can draw, read Iqra, spell his own name and many other basic words. He also has basic knowledge of number and his family really encouraged and supported him in daily learning.

Some observations on him while using the application are:

- Ammar seemed really happy to see the device which is the tablet as well as the mobile application
- He can touch the correct points on the screen after being instructed by his sister
- He can repeat using the application faster than the first time he saw it
- He wrote the numbers well on the "Practice" section and on the User Testing Form
- Did well in "Activities" part and be able to drag the correct answers
- Followed the finger's picture on the screen and said the correct numbers

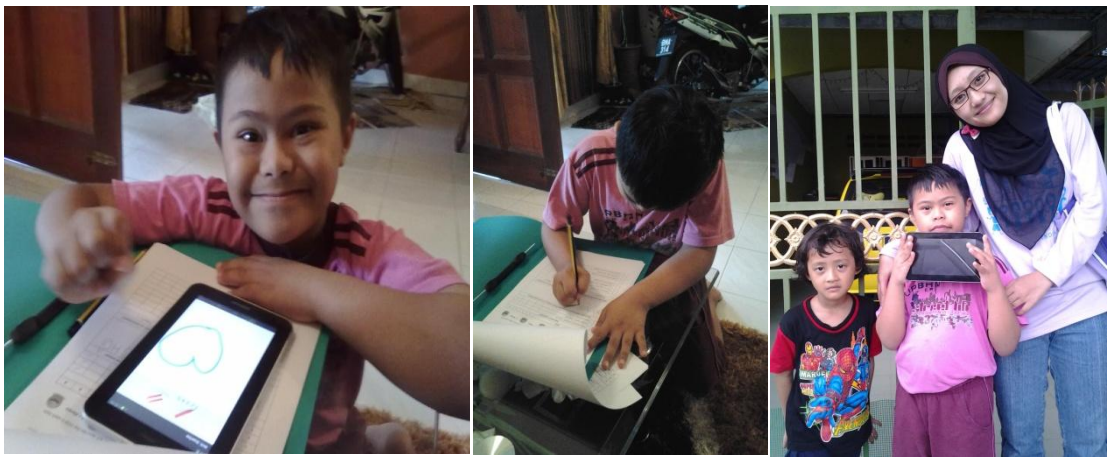


Figure 4.11: Respondent 2 (Ammar Rushdy)

Figure 4.12 shows that Muhammad Rizal is the third respondent. He can't communicate well but he can do household if his mom asked his to do it. At first, her mom said he can't count properly but after using the application, he was able to write and recognize numbers well.

Some observations on Rizal:

- He likes to write number 1, 2, 3, 5 and 6 with underline below the numbers on the User Testing Form.
- His facial expression is happy while using the mobile application
- He can perform correctly drag and drop activities after gone through "Learn" section. This shows that he recognized the numbers well
- He had difficulties in touching the 'TouchPoints' as the button were consider small by him
- Took different time in completing the activities of the application

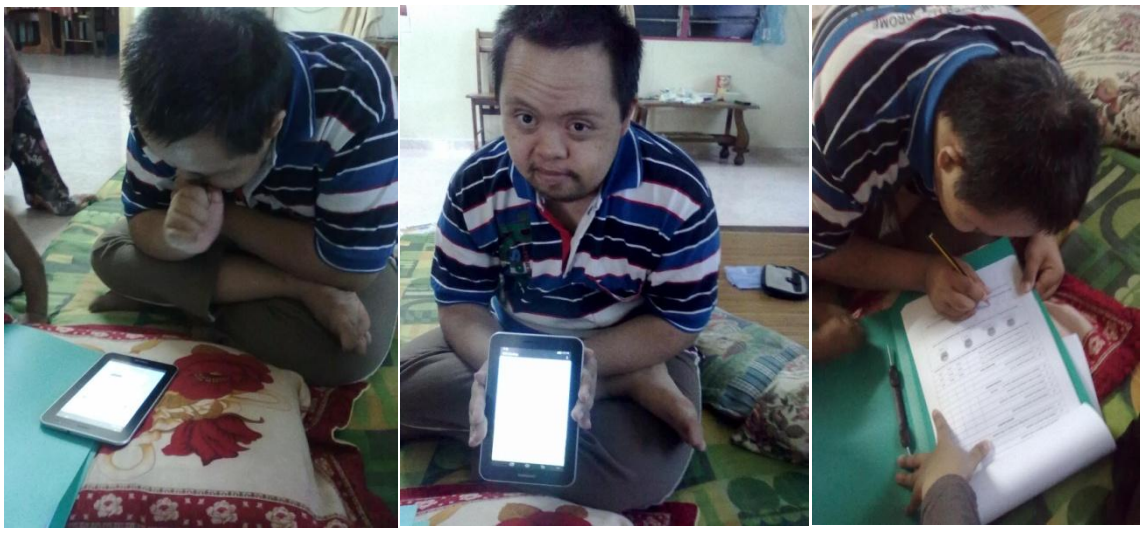


Figure 4.12: Respondent 3 (Muhammad Rizal)

Based on Figure 4.13, the fourth respondent is Mohd Faiz Fahmi, 9 years old. His face is just like normal people but he is a disable child who can't even speak and interact. He is a slow learner. He also cannot understand and focus on what people say, easy to get angry and needed his mom to manage his daily routine. Her mother told that he was affected by specific medicine when he is 1 month old in his mom's tummy.

Observation on Fahmi:

- He was in the bad mood during the testing time
- He loves to play with his blue clothes
- Seems not interested on the mobile application
- He cannot touch on the Tablet screen
- He cannot understand the instruction and lose focus easily

Figure 4.13: Respondent 4 (Fahmi)

In Figure 4.13, the last respondent is Mohd Nor Hazim, 10 years old. He is also a disable child with normal face not like Down Syndrome children. He can interact with people and he is so friendly. Hazim seems so interested to see the application and some other observations are as below:

- Can touch the right points well
- For the first time using the apps, he needed his mother to instruct him
- After several screens, he can understand the apps well and recognize numbers
- He cannot write numbers properly but can do circle and scratches

Figure 4.13: Respondent 5 (Hazim)

4.5 Discussion of Findings

As attached in Appendix section, a User Testing Form was designed with certain elements that were used as the observation checklist. Please refer Appendix 1. General questions have been asked to the user's parents and some of data gathered are as below:

- The age of most of the mother when DS child was born is 40 years and above
- Most of them are the second last and youngest child in the family
- All of the respondents going to school

Figure 4.15 below are the indicator represented with four scales as the reference to evaluate the users.

Figure 4.15: Four scales of indicator to assess the users

The first element that have been observed and assessed is the respondent's expression. Based on the observation, only one out of five respondents was in the bad mood and showed no interest to the application. The other four were so happy and excited to see the mobile application. This shows that respondent's emotion was varying and cannot be predicted.

The second element is respondent's basic numerical knowledge. Before they used the application, they were asked to write number 1 to 5 in the space on the form. Three out of five respondents know how to write basic numbers with the guidance from observer and their parents. The other two does not have basic numerical knowledge and cannot write on the paper.

The next element is the evaluation on their ability to use the application and their reaction towards the user interface. For the first time using the application, most of the respondents needed guidance from people around them to search and click for the right button on most of the screens. After using the application for second and third time, they

can recognize and understand the buttons well. This proves that DS users need behavioral concept to assist them in learning.

On the “Learn” section, three of the respondents can repeat the number’s sound well even their voice was not so clear. They touched the right points on the numbers and able to count the fingers displayed on the module. Besides that, they also seemed so familiar with the objects pop-out on the screens. A comment from one of the respondent’s sister was to make the sound instruction shorter, precise and louder. The touch points buttons also will be made bigger for the easiness of the future users. The application will be modified to suit the needs of future users.

For “Activities” section, three of them can drag and drop the right pictures and be able to count and choose numbers correctly, while, the other two respondents cannot cope in doing the activities. Most of them also can doodle and write numbers on the “Practice” section and this proved that they were able to recall what they learnt before. The speed and time taken in doing the activities were different. They took longer time like 10 minutes to 15 minutes for the first attempt and took shorter time after several time using the application. Their cognitive and constructive ability were tested in these sections. After using the mobile application, four of the respondents showed happy feeling and can recall and write again number one to five correctly on the User Testing form.

Thus, what can be concluded from the User Testing are, the mobile application is very suitable to be used by a moderate level of IQ Down Syndrome users. They need guidance from teachers and parents for the first time using the application and this applies the behavioral concept. Other than that, cognitive and constructive learning theories that have been included in the application really help them and proven effective in recognizing and counting basic numbers throughout their learning process. Furthermore, the respondents were attracted with the use of technological device such as tablet that can retain their interest level longer compared to pen and papers method. For the low level of IQ users, they must be guided properly and patiently by their guardian or teachers while learning using the mobile application as they can’t understand and focus well. Besides that, some user interface screens and sound instruction have to be adjusted according to the user’s requirements data collection at the end of the testing.

CHAPTER 5

FUTURE PLAN AND CONCLUSION

5.1 Future Plan

Some interface and functionality of the application are expected to be improved after the test which is specifically aimed for betterment. The bugs and error of the project must be fixed before releasing the application to be used by the real users for learning. Among the errors is sound instructions have to be made shorter, clearer and last long. Animations for instructions also can be included to make the application more interesting as future users does not need instructor anymore to guide them. This improvement will make the application more reliable. Besides that, the development of the second version must be continued which is from number six to ten according to the effectiveness of the first version. After the project has been developed, a User-Acceptance test must be conducted again and to satisfy the RAD method.

5.2 Conclusion

As a conclusion, by referring back to the objectives stated previously, several problems statements regarding the project have been addressed and achieved through the comprehensive Research Method which is Rapid Application Development (RAD). To make it clear again, among the objectives are, to identify suitable learning theory to be used in developing numeracy conceptual framework for Down Syndrome children, to develop a mobile application on learning the basic of numbers and to evaluate the user acceptance on the developed mobile application. At the end of the project, the most suitable learning theories identified effective to Down Syndrome children are

behavioral, cognitive and constructive learning theories. They can be used in designing the conceptual framework for DS children. It is proven based on the research done on literature review of their learning theories and User Acceptance result conducted to several types of respondents. Besides that, as a personalized system, this mobile application on numerical skills has been developed which is a new way to assist them in knowing and learning basic numbers. Hopefully, this mobile application with the suitable learning concept will be beneficial and can help as well as support Down Syndrome children in learning mathematics.

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APPENDIX 1

Observation Checklist for User Testing on Number Skills Mobile Application

Name: _____ Age: _____

Gender: ☐ **Male** ☐ **Female**

Part A: Based on the observation, tick (/) the appropriate scale that will describe the child in each item.

Scale: 1 = Never  **2 = Sometimes**  **3 = Often**  **4 = Always** 

No.	Items	1	2	3	4
Respondent's Expression					
1	Facial Expression: Frown(1) Smile (4)				
2	Emotion: Sad (1) Happy (4)				
3	Seems interested				
Respondent's Basic Numerical Knowledge (Write number 1 to 5 in the space below)					
Child's basic numerical knowledge in writing numbers 1, 2, 3, 4 and 5 (By Parent/s or Interviewer)					
Do not know [ ]	Good [ ]	Expert [ ]			
Home Page & Menu Page					
4	Search the right button				
5	Click the right button				
6	Face difficulties in searching button				
7	Understand the menu page				
Learn Section					
8	Understand the instruction (Sound)				
9	Touch the right "Touch Points"				

10	Familiar with the numbers and objects				
11	Able to count objects in the module				
12	Repeat the sound of number				
13	Touch points & Count using fingers as shown in the module				
Activity Section					
14	Understand the instruction (Sound)				
15	Can drag the pictures				
16	Able to count and choose numbers correctly				
17	Able to cope in doing the activities				
18	Speed in doing the activities: Slow (1) Fast (4)				
Practice Section					
18	Can recall number 1 to 5				
19	Can write numbers correctly				
	Recorded Time				
20	Completion time of using the application (1st try)	hour	mins	secs	
21	Completion time of using the application (2nd try)	hour	mins	secs	
22	Completion time of using the application (3rd try)	hour	mins	secs	

Assess the feeling/reaction of the child after using the mobile application (By Parent/s or Interviewer)


Frustrated


Bored


Good


Happy

Able to recall number 1 to 5 after using the mobile application (Ask respondent to write here)

After using the mobile application, assess the child's ability to recall the numbers 1, 2, 3, 4 and 5 (By Parent/s or Interviewer)

Cannot understand [ ]	Good [ ]	Expert [ ]

Part B: Please answer the following questions (For parents)

1) **Number of children in family : _____**
2) **DS children: _____ from _____ siblings**
3) **Age of mother when DS child was born: _____**
4) **Any relatives who have Down Syndrome:** YES [ ] NO [ ]
5) **DS children going to school:** YES [ ] NO [ ]
6) **Behavior of DS children:** _____
   _____
   _____
   _____
   _____
   _____
   _____

Part C: Comments from teachers/parents

1) Interface:_____
2) Function:_____
3) Sound:_____
4) Activities:_____
5) Suggestion:_____