Augmented Reality Mobile App for Children Learning on Colour

By

Muhammad Helmi bin Jamaludin 16300

Dissertation first draft submitted in partial fulfillment of the requirements for the
Bachelor of Technology (Hons)
(Information Communication Technology)

JANUARY 2015

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CERTIFICATION OF APPROVAL

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Approved by

_____

(Dr Dayang Rohaya bt Awang Rambli)

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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MUHAMMAD HELMI BIN JAMALUDIN

ABSTRACT

This document describes the process developing an Augmented Reality (AR) of mobile application on colour by using storybook. By using camera on the smartphone or tablet, the user or the child could view the superimposed virtual three dimensional (3D) objects and images in a fun and interactive manner using the marker-less physical colour book as the interaction tool. Learning colour since young age helps children to distinguish colours and they can choose their favourite colours. In addition, it helps them to express themselves, build the confident and more easy-going by choosing the desired colours. Otherwise, they will be tend to have difficulties in making choices in their future life. Many researchers and journalists have done their research on the topic and emphasized on the importance colour for children in the early age is beneficial for their successful in future.

Thought there are a lot of great deal of technology based on colour book, parents still prefer buying the physical books because they think it is the most effective way to teach their children on colour. The problem is that though the physical book possesses many benefits especially to our generation and generation before, yet from the current children generation's perspective, they might find it with dull and not interesting. This is because commonly familiar that the current children's generation are surrounded by technologies and gadgets, which easily distracted and might refuse to use plain non-technology book to learn compared to the book with have the technological one. Therefore, it is significantly shows that the use of Augmented Reality should be implemented to solve such problems. Augmented Reality technology is considered good for both worlds, real and virtual where the objects are combined in the real environment and can be viewed in 3D. It allows the combination of technology based on mobile application and the traditional physical book which benefit to both of children and parents interesting on the new learning way. Although AR technology is quiet new, it is potentially have the place in market especially for education and it just of the beginning to be further explored.

The main objective of this research is to develop an interactive and more fun 3D colour pop-op books using digital storytelling. It is could enhance the children interaction on colour physical book by creating Augmented Reality mobile application that contains animated interactive 3D objects and audio based on interesting storyline storybook. In addition, the project is to investigate the augmented reality technology

effect on the children's learning engagement. The scope of the project is wide, which are including 3D modelling, texturing and animation, book design and content research, and of course augmented reality and mobile application development. The user requirements are collected from the targeted users, which are children and some information gained by parents and preschools teachers. In conclusion, the project is achieved the objectives and able to attract interesting among children on learning colours.

ACKNOWLEDGEMENT

First of all, I would like to gratefully thank to Allah for allowing me to complete the project throughout the duration given. I also would thank to my supervisor, Dr Dayang Rohaya bt. Awang Rambli who helped and guided me along these two semesters for finishing the project. Furthermore, my gratitude thanks goes to my family, friends and whoever that involved and contributed in the project, especially the respondents, teachers, parents and also children. Definitely, the project cannot be success without all of these supports and helps.

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Augmented Reality Mobile App for Children Learning on Colour

1.0 Introduction

1.1 Background

Children's formal learning education starts with pre-school education. Preschool defined by (Wikipedia, 2014) is an educational establishment that offering early childhood education between age of three to six which is prior to the commencement of compulsory education at primary school. It is an education program that provides the learning experiences of children aged 4-6 years in duration of one year or more before going into Year One in formal school. Preschool education concept is "Learning While Playing" emphasizing "Themed Learning". The learning methods are included classroom activities, group activities and individual activities. It is unique because it focuses on group activities that seek of improvement in intellectual quality and emotional control. Disclosure of the learning education that organized by Ministry of Education (MOE) is to provide a strong foundation for learning the concept of smart school.

There are several basic core modules that emphasized in preschool education, such as basic reading, numbering and colouring. Colour is one of them and this research paper will more focus on this core module which is related to the project. It is very common for every kid to learn colours since they are young. Learning and knowing colours is important as a jump-start to know an object with their respective colours. Most of the time, parents acknowledge their children by showing the object with mentioning the colour. For example, parents show the red flower and saying "It is red flowers", so that their children will recognize and acknowledge that is the red flower. Children are more interesting on colours because they would love on looking at colourful pictures or books. By teaching them the correct colour of the object, they can easily remind and plays with the colour of the objects.

The learning will be more interesting and interactive to children if it is implemented by augmented reality. Augmented reality is one of the emerging technologies that are widely used nowadays in many fields such as medicine, advertising, travel and also education. It allows users to manipulate and retrieve data

onto the real world, also experience the realness of an idea without endangering consequences. In education fields, augmented reality is able to provide interactive, interesting, and fun learning to attract students and children with guarantee the higher possibility of understanding and enjoying the subject being taught.

1.1.1 What is colour?

According to (Wikipedia, Color, n.d.), colour is the visual perceptual property corresponding in human that derives from the spectrum of light that interacting in the eye with the spectral sensitive of the light receptors. Another definition of colour is the property obsessed by an object of producing different sensations on the eye as a result of the way it reflects or emits light (Oxford Dictionary). Colour learning starts from the early age whereby the children can notice the similarities and differences of the shape and size. Basically, children are enjoyed looking on colourful books or pictures. Besides knowing the basic colours, they can also differentiate and identify the colours based on the various objects. This research paper more concentrates on the learning education of basic colour for children aged from 3-6 years old which are eligible for pre-school education.

1.2 Problem Statement

Firstly, the traditional physical books that currently use is static, which means only contain certain images and their basic colours. They tend to feel bored and not to stay focus with the learning way even it still the effective and easy way. Children's generation of this era is surrounded by gadgets and technologies, therefore, it would be interactive and more interesting learning style if the technology is implemented to gadgets, such as mobile app on augmented reality.

Generally, learning colour towards children will enhance their intellectual and cognitive processes such as able to pay attention on learning and able on determine the uses and functions of colours. However, (Zlotkowska & Cassidy, n.d.) emphasized that cognitive processes are more likely if the children are been taught about their preferable colours.

1.3 Objective of Study

The objectives of the project study are to create a variety of learning methods to teach colours. Therefore, the project is to develop a fun and interactive AR colour mobile application for children focusing on age 3 to 6 years old to learn and understand the colours. The project is about to develop an AR mobile app with using of storybook that teaches the concept and use of colours. For those children ages, the project only focuses on the conception of basic colours and their importance in real life by playing around the colours to the object. The specific objectives of this project are as follows:

I. To create an alternative and improve the current traditional learning way on colour by using Augmented Reality mobile application.

II. To develop an Augmented Reality mobile application for children learning on colour.

III. To validate the use of AR application in engaging the children in terms of identifying colours, and investigating the children's interesting on learning colours.

1.3.1 Significant of the project

The problems should be solved in order to grab children that more advance with gadgets and technology and get bored easily with traditional learning process.

Current methods of learning for children obviously show a different gap between the advanced technologies nowadays. (Yeomans, 2014) agreed that children nowadays are more tend to use gadgets in their learning education. In fact in South Korea, the children from age's three to five will be taught to avoid spending much time on gadgets due to digital obesity (Yeomans, 2014).

Figure 1: 70% of children already confident in using gadgets by the time they start school (Gurney, 2013)

The problems should be tackled as kids nowadays are more advanced and get bored easily if the learning process does not run efficiently. They are exposed to various technologies advancement, which is also a lead to have different expectation on the learning process. Therefore, the common current methods of teaching the colour are worrying the parents, because their kids seem uninterested and do not want to learn the colour, which is the core basis of learning of nature and its colours.

Thus, an interactive digital storytelling colour application books should be developed to allow the kids to have fun and engaging learning process. By using augmented reality technology is the best of both worlds combines both virtual and real environment to give a magical mixture that combines both virtual and real environment benefits.

1.3.2 The Relevancy of the Project

Augmented reality offers the new form of learning process making it more interactive, and interesting. The project aims to integrate the AR technology as learning tools. For the time being, the project will be developed based on recognizing the colour and learn how to match them with coloured objects.

Generally, the application will offer the children to read the AR books using the Android tablets or smart phones. With the advancement of AR technology, kids will be

able to manipulate and interact with the virtual views of the book; thus making the learning becomes more exciting. If the project is successfully developed, the AR book can be readily used by the kids and the user's perception study will be done accordingly. With the success of the project, the learning process should definitely be more fun, exciting and interesting.

1.4 Scope of Study

The objective of this project is to develop an interactive mobile application based on Augmented Reality on colour learning for children at age 3 `` to 6 years old. The learning contents will be designed specifically for those ages to help them get an early understanding and differentiate the function of the colour in real life. The scope of this project involves several areas that will be used in development as follows:

I. **Augmented Reality** is defined as the combination of real scenes and virtual scene. It means the real scene is viewed by user and the virtual scene is generated by a computer that augments the scene with additional information. Thus, the project aimed to develop mobile application on colours using the AR technology.

II. **3D Design Software Development Kit (SDK)**

The software that will be used to design and develop 3D images for the app. The SDK that is going to use is Blender Software and Unity 3D Software.

III. **An Android (Mobile) Applications & Interaction**:

Since the Mobile technology is now available and very useful and affordable and not only adults are familiar with the use of such devices you can find 4 years olds carrying their smart phone and playing around with it. Thus, the project aimed to develop AR application on Android tablet instead of using the PC or computer. Since Android operating system is an open source and Google releases the code under the Apache License, it is the most common used operating system for smart phones rather than iOS (iPhone operating system). With the completion of the project, kids will be able to use the application embedded on their Android tablet while enjoying reading the AR books.

IV. **A physical storybook** will be used as the marker images of the app. It will contain the storyline that will attract and retain children interesting to learn and play around with the mobile app.

1.4.1 Feasibility of Project within timeframe and scope

In conclusion, the target users for the application are the children with age ranging from 4 to 6 years old, which are preschool students as well as early primary school students. The project is aimed to allow children to more understand, ease and faster the learning education on colour. By implementing AR in the project, the target is children will be able to learn the basic concept of colour in fun and best way by interacting with the 3D models.

The project will be developed within two semesters as in eight consecutive months. The first four months will involve the first few phases of the methodology process, which are planning, analysis and designing phase. Meanwhile, the second phase of the project will be more focused on developing and implementation application, then testing phase. Therefore if the tasks are properly managed and the time is wisely allocated, the project should be feasible within the timeframe as shown in the Gantt chart.

2.0 Literature Review

2.1 Theory of Augmented Reality

Augmented Reality (AR) is defined as the combination of real scenes and virtual scene. It means the real scene is viewed by user and the virtual scene is generated by a computer that augments the scene of additional information. In other words, it is superimposing a computer-generated image of a user's view of the real world, thus it will provide a merged view.

According to (Wikipedia, Augmented reality, n.d.), AR is live direct or indirect view of a physical or real-world environment whereby the elements are augmented by computer-generated sensory input such as sound, 3D graphics or GPS data. As a result, it can enhance one's current perception of reality towards objects. The advancement of AR technology allows the information about the surrounding real world becomes more interactive and digitally manipulable. However, (Wu, Lee, Chang, & Liang, Mar 2013) claimed in their article "Current Status, Opportunities and Challenges of Augmented Reality in Education", that observing AR as a concept would be more valuable for the users rather than a type of technology. They tend to identify the features and affordance of AR applications.

In another sources, (Dartmouth Collage , 2015) defined that AR is the addition of computer-assisted background layers of information over the real world which producing a reality that is augmented. He also stated that there is an unlimited potential improvement on AR in the technologies advance era.

2.2 Concept of Augmented Reality

Augmented Reality starts when the camera is being used to recognize for markers or an image in a real world. The position and orientations are then calculated to augment the reality. It is then identifying the markers which are the symbols of the marker are matched with the templates in memory. The identified marker is position and orients the objects before transformed by 3D virtual objects to align them with markers. As a consequence, the virtual objects are rendered in video frames or screen whereby the user can view the object in 3 dimension. The flow on how augmented reality working is shown in the picture below.

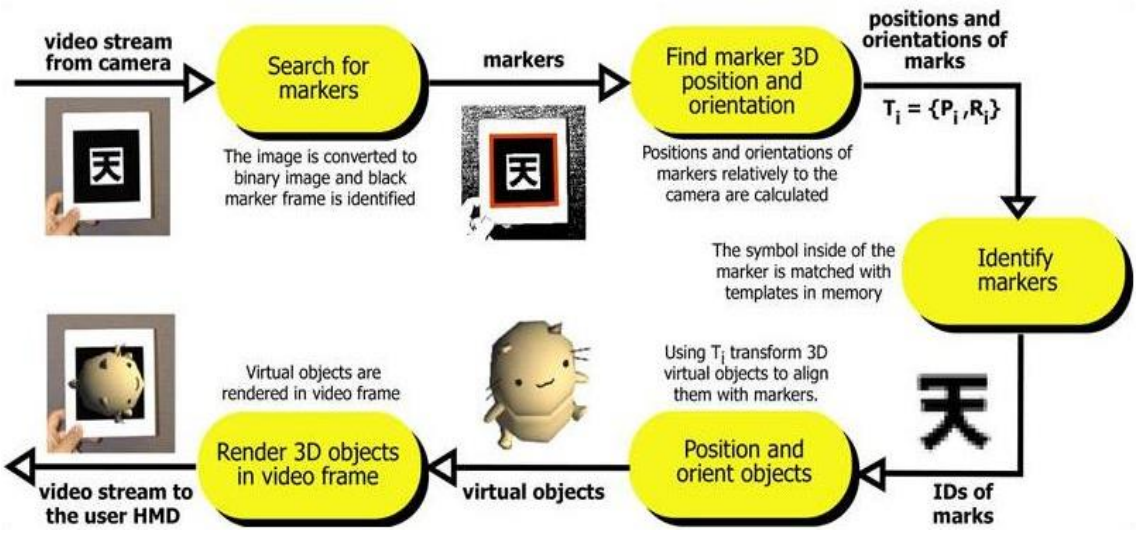


Figure 2: Flow of Augmented Reality works (021 bitmarkz, 2011)

2.3 Hardware and Software of Augmented Reality

A key measure of AR systems is how realistically they integrate augmentations with the real world. The objective of AR is to enhance the information and gives good consequences of a real object or places. Therefore, the hardware and the software uses are very important to do AR project. The main hardware components for AR are a processor, display, sensors and input devices. All of these components are available in modern mobile computing devices such as smartphones, and tablet computers. These devices contain the elements which often include a camera, sensors like accelerometer, GPS which is making them suitable for AR platforms.

Tools or hardware used for the project are as the following:

- A webcam to capture and detect the markers
- A monitor to view the captured image
- An AR book or flashcard with embedded with marker.

For the software part, it must derive the real world coordinates besides independent from the camera. The software application development environment is needed to augment and combine with the 3D modelling. The software development kit

is mainly function to enable rapid development of AR application. There are several well-known SDKs for AR such as Metaio, Unity 3D, Vuforia, Blippar and Layar.

Software for the project

- Metaio Creator SDK, a desktop tool or software development kits to create and publish AR scenarios.

- Unity 3D, a cross-platform game engine with a built-in integrated development environment (IDE) developed by Unity Technologies. It is used to develop video games for web plugins, desktop platforms, consoles and mobile devices. The powerful Unity 3D is used to compile all the above list of software, programs and SDKs, to design the application. In this project it is useful for creating the AR application that integrates with the 3D models created using Autodesk Maya.

- ARToolKit, a computer tracking library for creation of strong augmented reality applications that overlay virtual imagery on the real world.

2.4 Types of Augmented Reality

According to (Albright, n.d.), there are two main types of AR applications that are generally use, which are marker based and markerless. However, (Campanelli, 2010) have some additional opinion about her article titled The 3 Types of Augmented Reality for Marketers, which includes of Augmented Vision that used smartphone AR apps. Basically, the augmented vision is almost same with marker-less AR but it use of smartphone AR apps such as Goggles and Layar which point the smartphones in any directions, view through the camera and reveal the information about the picture or graphic visualized. Yet, both marker-based and markerless AR requires their specific advantages on the function. For example, marker-based is the most predominant and easiest to achieve meanwhile the markerless is keep on developing with limited due to certain sensor accuracy.

2.4.1 Marker-based AR

This type is use of visual marker and the camera. Albright mentioned that the marker based application is normally utilizing images or visual marker that will produce a 3D image when it pointed by user, normally by using a camera on a smartphone. The viewer or user holds up the content to the camera to view the AR in action. The advantages of marker-based are most dominant and easiest to accomplish. It is much simple to detect the marker that hard-coded to the mobile app and able to compute the pose matrix such as rotation and angle which user can view the virtual model of object at different angles on the device. Examples of using marker-based AR can be shown in the Mini Cooper advertisement, as picture below.

Figure 3: Marker-based AR example (Scribble, 2011)

The following applications are the more advanced examples of Marker-based AR:

- Popcode takes the object in the real world and connecting with the virtual world which the users can find, interact and explore the additional information contents that embedded to the objects (Albright, n.d.).
- Google Goggles recognizes images scanned by smartphones, which can bring up information about an image that captured early by phone camera (Albright, n.d.).

2.4.2 Markerless AR

This type of AR is using a graphic environments instead of markers and it is more dependent on the capabilities of the device being used such as GPS location and velocity meter. It can be implemented by using the existing graphics to present AR ads and viewer can see the AR easily. It is a halfway of technology triggers whereby smartphones have the combination of GPS and compass. Therefore, the users know the location and direction it augmented on the screen clearly and correctly. However, the current marker-less AR is limited due to the sensor accuracy, service limits, and bandwidth requirements and also the power pulls on the devices.

The examples of Markerless AR are Wikitude from Mobilizy and SPRXMobile, the mobile services that use of GPS-Compass based.

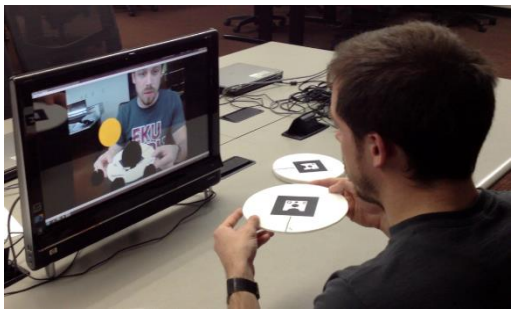
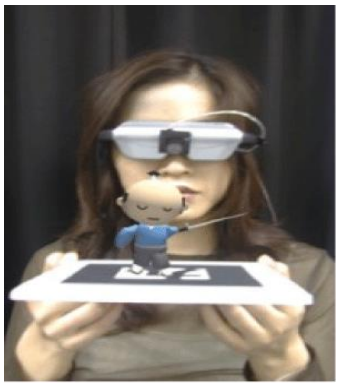
Figure 4: Markerless AR example (Retrieved from https://fluffystrawberry.wordpress.com/major-project/)

The following applications are the more advanced examples of Markerless AR:

- Augmented Reality Interactive Storytelling, ARIS is open source program that use a Flash based browser interface, enables users to create AR games, tours and other imaginable interactions for delivery only on the iPhone or iPad 2,which the Apple products (Albright, n.d.).

- Aurasma is available for Android and iOs users to download the application which uses the smartphone's GPS, camera and other features to recognize the surrounding area and display the interactive AR content without scanning the barcode (Albright, n.d.).
- Layar is available for iPhone and Android based smartphones as well as Aurasma which displays digital information called "layers" in the users' field of vision through their mobile device (Albright, n.d.).

2.5 Devices used for Augmented Reality

Desktop	 *Figure 5:AR using desktop*
Head mounted devices	 *Figure 6:AR using head mounted devices*
Mobile Devices	 *FIGURE 7: AR USING MOBILE DEVICES*

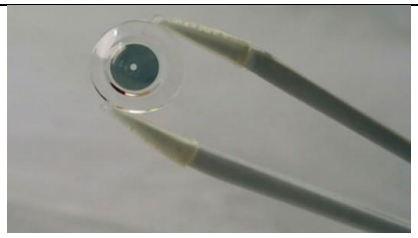
Eyeglasses	 *FIGURE 8: AR USING GOOGLE GLASSES*
Contact Lenses	 *Figure 9: AR using contact lens*

Table 1: Table of AR devices

2.6 Augmented Reality Application

Nowadays, augmented reality has been broadly applied in various fields including medical, architecture, advertisement and commercial, education, games and many more.

2.6.1 Medical Application

Augmented Reality in medical gives many benefits and advantages to the patients, doctors, and involved parties. The benefit is not only can help save lives, even also help healthcare organizations' processes more precise and efficient. It also improves the medical training to making pharmacy management more effective (Sangen, 2014).Based on the research that was conducted, this AR was used for helping doctors to conduct surgeries more effectively, improving fitness, besides as a teaching material for medical students.

Figure 10: AR in surgeon process example

In terms of surgery process, AR can efficiently help surgeons in terms of precision when conducting a minimally aggressive procedure or locating a tumour in liver. It is also providing them with information, such as showing the heartbeat rate, the blood pressure, the state of patient's organs and many more. Thus, it can help save lives and treat the patient seamlessly.

According to (Lewis, 2013)in his article, the AR application in medical can enhance patient education and also care management. It was supported and related to the implementation of EyeDecide, a medical app that created by OrcaMD, a company that producing a range of high quality patient education apps. The app helps educate patients in a new way which is uses the camera displays for simulating the impact on specific condition on a person's vision. In that case, the user is demonstrating the impact of Age-related Macular Degeneration (AMD), a medical condition that results in a loss of vision in the centre of visual fields (the macula) because of retina damage (Wikipedia, Augmented reality, n.d.) or Cataract.

Figure 11: EyeDecide app

In medical learning or training, AR can be used to allow students to have better understanding of human bodies and how it functions. For instance, an AR app can help overlay the digital information on human skeletons in the form of video, audio or 3D models.

Figure 12: Example of AR in medical learning

The advantages of augmented reality in patient education as follows:

- Patients can visualize the doctor or the pathology is taking about

- A multi-sensory experience has been shown to be more effective in transmitting information (Shams et al, 2012)

- Patients can see how a potential disease would impact them in natural surrounding e.g. : testing their vision at home

However, there is still having the disadvantages or difficulty of implementation of augmented reality in patient education:

- Not all conditions are amenable to AR

- Requires a certain amount of digital literacy to truly understand what AR is

2.6.2 Games

Augmented Reality itself enhances physical surrounding in real time, which is live and direct or indirect view of real-world environment where the elements are augmented by computer-generated sensory data such as video, audio, GPS location and images. Therefore, it is now combines the real world to the game.

In the past 10 years, the technology has improved rapidly, such as the mobile device and smartphone application which resulting better movement detection and graphic design. As a consequence, many game developers around the world are competing each other by incorporating AR technology into their games. In gaming, AR allows gamers to experience digital game play in real world environment (Wikipedia, Augmented reality, n.d.). (Petty, 2014) thought in his article that AR games allow players have a unique perspective, innovative gameplay options and the ability to interact with games directly rather than using keyboard or controller. The statement is strongly agreed by (Young, 2013) which the rapid growth of technologies nowadays, the electronic games industry and the social media industry are broadening their scope and in fact would become a trend very soon.

There are many AR games developed and available in market. The lists below are the example of AR games:

- Google's Ingress for iOs – geo-location based AR game which is transforming the real world into the landscape for a global game of mystery, intrigue, and competition.

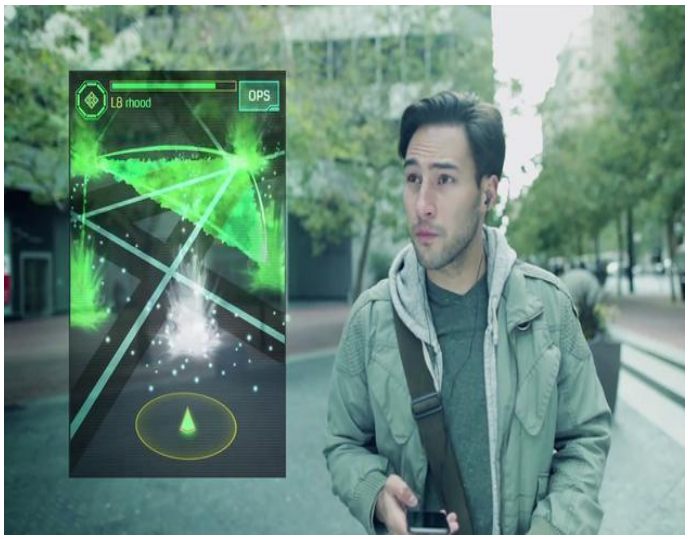


Figure 13: Google's Ingress

- Table Ice Hockey – PlayStation Store's top rated AR game that put an entire hockey rink anywhere which can view from any angle.

Figure 14: Table Ice Hockey

- Kinect – a line of motion sensing input devices Xbox 360 and Xbox One video game consoles and Windows PCs (Wikipedia, Augmented reality, n.d.). It enables users to control and interact using their console or computer the need of game controller, through using gestures and spoken commands.

Figure 15: Kinect Game

2.6.3 Advertising and Marketing

Nowadays, augmented reality has been dominated by advertising and marketing field widely especially in car and furniture advertisement. Many companies are seeking new ways and take the opportunity to use the technology in order to boost sales and promote their products. By using the technology of AR, it definitely can attract customers' interest and encourage them to engage with the goods or services before purchase.

AR application enables users to view the virtual objects, apparently sharing their space, which can be discovered and manipulated using natural movements and hand gestures. Furthermore, technology of mobile devices nowadays enables users to use their smartphones to view, rotate and resize the virtual image of products. As for example, it can be used for furniture advertisements so that user can gain more precise impressions or view on how the item would complement for furnishings and decorating the furniture.

Figure 16: Example of AR application for furniture advertisement

Figure 17: Another AR application in Nike advertisement

2.6.4 Travel and Tourism

Normally, people are preferring and familiar with using on-board GPS systems or online search apps to find location while driving and travelling. With AR, it is beneficial to enhance user's experience navigating in the real world. It was supported by (Sung, 2011) which is the rising of smartphone leads the technology to ease people walks around with the travel guide applications without hard copy maps. The single-pocketable device has become travel guider with having all Internet-based information such as maps, telephone numbers, address books and the backbone of information.

Some may ask why AR technology could be better used for travel and tourism. According to LonelyPlanet Travel Editor Tom Hall, it is about keeping the eyes which can help in both practical and inspirational ways. In addition, travelling using AR apps not only help people to find places and sights that may otherwise be tricky, it even gives users a new route into accessing travel information.

Figure 18: Example of AR in travel and tourism

2.6.5 Education

As well as other applications, Augmented Reality also can be used in education field in many kinds of level of studies. The AR app can complement a standard curriculum which contains text, graphics, and video and audio that can be superimposed into a student's real time environment. There are many advantages of applying AR app in education fields. According to (Ramirez, 2011),user can see and touch the real manuscripts and able to interact with a core primitive text via visual triggers such as augmented 3D models that overlay the physical image and require user touch gestures. There is also stated in (Wikipedia, Augmented reality, n.d.) that students can participate interactively with computer generated simulations thus can engage and motivate them to explore class materials from different angles.

In addition, (Ramirez, 2011) believes that AR can promote the collaboration between students and teachers and encouraging critical response and the adoption of new perspectives and position. This is really opposite compared to traditional

educational methods which are predominantly teachers led the learning process. This is an active learning process which the students learn to learn with the technology. The AR can be used in many different levels of years. For children range between of 3 to 7 years old, AR apps can enhance and entertain them to keep motivate and gaining their interest to study and learn. According to (Jade, 2014), one interesting fact about young children is they have a good of imagination. They also have no trouble on pretending, playing make believe and suspending the reality in their minds. In terms of high level education students, AR can aid the student in understanding the topic by visualizing the spatial structure and interacting models of it that appears in camera image. Furthermore, it is also enabling physiology students to visualize the human body system in three dimensions.

(Jade, 2014) added in the article which is according to Shameena Parveen, the co-founder of EduTech, she believes that in order to develop the needed skills, the students should be exposed to the more active and participatory learning method which students can have the 'learning to learn' skill. It is much related to the augmented reality application in education whereby students can participate and learn directly. Indeed, study by using augmented reality can attract and gain children focuses in learning.

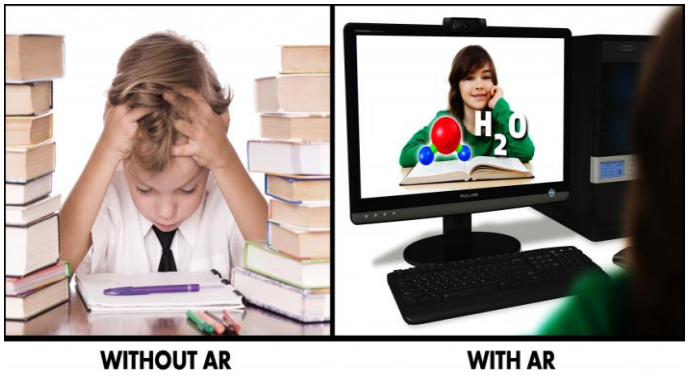


Figure 19: Difference of children study using AR and without AR

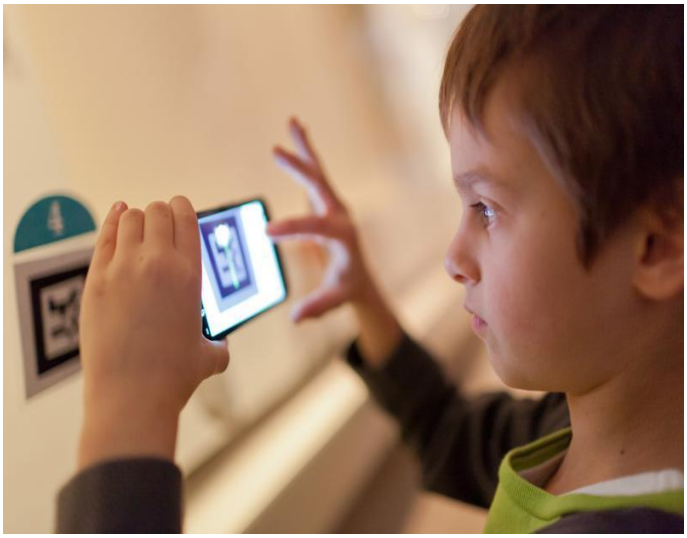


Figure 20: A picture shows a child focuses use AR application

2.7 Current Mobile Apps of Augmented Reality on Colour in Market

Colour books or storybooks always been one of the first books that every child would own. The parents are mostly wanting their children be familiar with the colours prior their pre-school entry. Currently, the technologies have been developed and mobile apps on children learning for colours also have been created for enhancing the traditional way. There are some available mobile apps in the market that give the basic exposure to children about the colours. However, the apps are not implemented with augmented reality, but still functioned well to educate and help children to more understand about colours.

2.7.1 Animal Pants

Figure 21: Screenshot of animal pants mobile app

This adorable apps is purposely built for pre-schooler and children with beautifully illustrated nature scene. The app provides several types of animals that need children's help to find their right size pants. Basically, children will learn the matching skills by selecting the correct pants for the animals. Other than it is a fun and interesting app, it is also available in four different languages which are English, Spanish, German and French which will helps to build literacy skills across those languages.

2.7.2 PLAY123

Figure 22: Play123 icon

One fact about this fun geometry app is it won a 2013 Editor's Choice Award from Children's Technology Review. The app is purposely built for pre-schoolers and also suitable for 2 year-old children. It came out with friendly voice guides children in various simple games about colours, numbers and shapes. However, the app is only available for iOS users.

2.7.3 Peek-a-Zoo

Figure 23: Example of peek-a-zoo interface

The Peek-a-Zoo app aims to educate children about emotions, actions and positions rather than simply trying to teach kids the names of the various animals featured in this stylish app. The app is the most likely like this project in terms of matching the animal colours. Examples include trying to identify the character of an image that is crying or hiding.

2.7.4 Colour Memory Match

Figure 24: Colour memory match interface

The app is created by collaboration of parents and teacher especially for their kids and children. It is fun and easy perfect teaching tool for colour identification and recognition skills that combines exciting card matching game play. It also includes professional narration, fun music and positive feedback that will notify both children and parents about the children's performance. There are several tasks in colour identification that includes in the app. The tasks are as the following:

- Match colours to colours
- Match colours to their name
- Match unique pictures that have same colour
- Hear the colours as you touch them
- Discover new colours, designs and layouts as you play
- Pop balloons and hear them count
- "Show Me" option keeps cards face up for easier play

Some additional features of the Colour Memory Match app are as below:

- Items, numbers and instructions are professionally narrated
- Hints and options allow you to customize difficulty
- Players are rewarded with balloon popping and positive encouragement
- Shape match games available for purchase
- Parental controls: Turn off sounds, music, purchases and links to our other apps
- We do not collect personal information from our users.

2.7.5 AR Flashcard Shapes and Colours

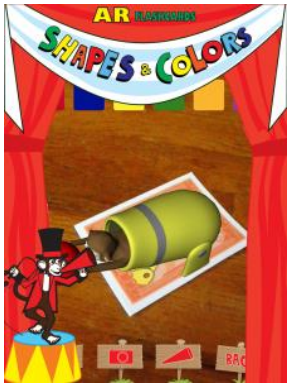


Figure 25: Screenshot of AR Flashcard Shapes and Colours

The new app that implemented AR gives a fun learning about shapes and colours using augmented reality. It has cool colour bars of the screen that will actively change a shape's colour by the press of a button. It also contains 10 rendered 3D models that help the toddlers or pre-schoolers learn their colours and shapes. The app is available on the Apple Appstore, Google Play and Amazon Appstore.

2.7.6 The Very Hungry Caterpillar 3D pop-up picture and story book app

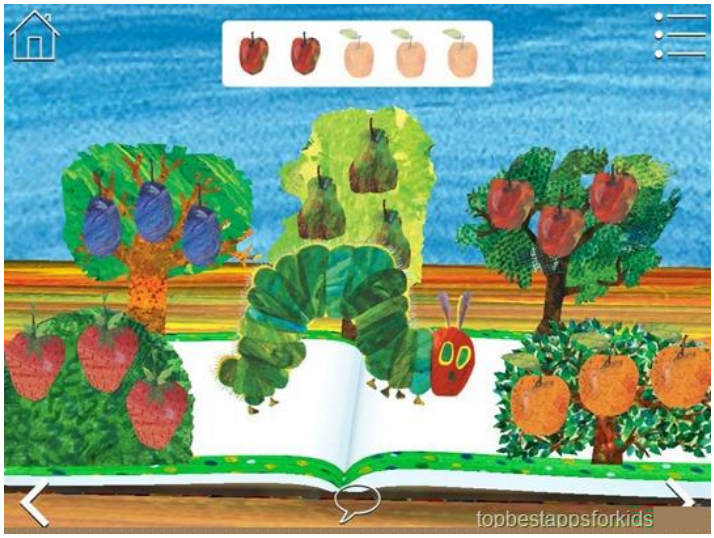


Figure 26: Screenshot of The Very Hungry Caterpillar 3D pop-up picture and story book app

The interactive 3D storybook app is purposely built for children and kids. The app developer, StoryToys includes with the interactive pages and colourful 3D images. It is also containing stories and some games that required users or children to be interactive with the 3D storybook app. The app is only available for iPad and iPhone on Apple App Store.

2.8 Comparison on available apps in market

Mobile app icon /Screenshot	Mobile app name	Features/Advantages	Disadvantages
 	Animal Planet By Alchemist Interactive LLC	• Fun and interesting • Allows children to know animals • Good graphic background and pictures • Available in various language	• Too complicated with the background design and graphic
 	PLAY123 By KinderTown	• Includes numbers, colours and shapes • Come out with friendly voice guide • Suitable for 2-year-old and above • Affordable	• The content is too simple and ease to get bored • Low graphic design • Less about colour

 	Peek- a- Zoo By Duck Duck Moose, Inc.	• Educate children about emotions, positions, and actions • Learn about animals	• Too slow and boring • No value added

 	Colour Memory Match By Eggroll Games LLC	• Includes the professional narration • Fun and give feedback to users • Discovers various tasks of colours • Parental control • Not collect users information	• Low graphic design

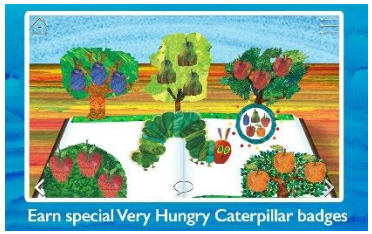
 	AR Flashcard Shapes and Colours By Mitchlehan Media, LLC	• Using AR • Have 10 beautiful rendered 3D images • Fun and interesting • Give the instruction to use	• The graphic of animal is quite low • Not very interactive
 	The Very Hungry Caterpillar 3D pop-up picture and story book app by Top Best Apps for Kids	• Fun and interesting • Have the stories and games • Colourful 3D images	• The design of characters are not interesting • Too complicated graphic designs

Table 2: Table of comparison of existing mobile app in market

2.9 Storytelling in Children Education

Storytelling in past has been taught to children as it is an efficient and effective way for children learning. This is emphasized by well-known genius people in history Albert Einstein.

"If you want your children to be intelligent, read them fairy tales. If you want them to be more intelligent, read them more fairy tales." - Albert Einstein (Albert Einstein Quotes, n.d.)

Storytelling in (Wikipedia, n.d.) is defines as the conveying messages in words and images often by elaboration. Telling stories to children without using a book will make them feel in a different world dimension because children love to hear the story (Myers, 2012) . Meanwhile, (Prokerala, n.d.) defines storytelling as an art that mentally, socially and educationally benefits for children. In order to make it more beneficial, the storytelling must include language skills which are good words that can attract children on the story. Myers agreed that children love to hear the story based on the story plot and also the rhyme besides the use of interesting and illustrative storybooks. Furthermore, storytelling helps in developing children's minds of imagination and creative thinking.

Storytelling gives benefits to children as their learning way of education. (Sen, 2014) and (Prokerala, n.d.) strongly agreed that it can introduce new words and vocabulary to children. Other than that, it can improve and brush up children knowledge that may use in future. Another important of storytelling are in the list below.

- Great activity of learning which transfer emotions and feeling and boost thinking capacity
    - ✓ Children may ask questions and they learn to associate between images and story and then imagination and visuals.
- Increased children knowledge
    - ✓ They can know about various types of knowledge other than getting to know the moral values and behaviours.
- Introduces new vocabulary to children

✓ The stories contain a lot of word with different level of vocabulary that very helpful in children learning and easy for them to learn faster from the context of story.

- Enhance the children listening skills

✓ Storytelling encourage them to participate actively and gives the essential learning to listen and understand instead of talking.

2.9.1 Digital Storytelling with Augmented Reality

Generally, storytelling is very important as it gives both entertainment and education for human being (Zhou, Cheok, Pan, & Li, 2004). The traditional storytelling is using storybook that enables the users involve in multi-sensory experiences such as speech which is the story, vision by seeing the book and also touch by turning pages and pointing to the books. The purpose to implement AR in the storytelling books is to improve the interactions and interactive learning in the sense of human computer interaction especially children while keeping on the advantages of traditional physical books. By using AR technology, it can be potentially boosting up students interactions with multiple modalities experiences including speech, 3D audio, 3D graphics and also touch.

Figure 27: Example of AR using physical book

2.10 Colour Learning for Children

A student especially children must understand and can differentiate the colours starting from knowing the basic colours. Part of that, they can recognize and identify the uses and functions of those colours in real life especially in drawing and colouring field. In the era of computers and gadgets technologies, the learning way can be various such as through electronic books, mobile app and also even online website. Generally, the colour storybook provides opportunities for preliminary knowledge of art and benefits to various application. They came out in such different exposure like giving the information, playing games, matching the colours, and also presenting in storyline.

2.10.1 Importance of Colour for Children Learning

Children must realize that the knowing of colours is very important in the daily life. They need to know which colours they enjoy the most and which of them the least. At least, it would be beneficial to them, imagine they have to choose colour to paint their room or their toys.

Colour helps children to express themselves (Stanisauskiene, 2011).She believes that the colour makes them more easy-going and more self-confident by choosing their favourite colours especially for their room, toys, and clothes. This is also supported by (Burkitt & Barrett, 2003) which that children can tell and express their feeling and expression through colours. On the other hand, children who are told when and where to use what colour by others will have tendency of difficulty on making choices in their later life.

Besides that, colours can teach them at a certain way of life. For example, if the children are surrounded by natural, rich colours and the colour tones met in nature, they can be taught to be respectful to nature and more eco-friendly. They also can think to recycle things, especially there are recycle dustbin that coloured according the material differences.

3.0 Research Methodology

3.1 Methodologies

The system development life cycles (SDLC) methodology that was chosen and used in this research is the Rapid Application Development (RAD) approach. It was decided once a lot of consideration made in terms of gathering the requirements and the nature of application development. RAD consists of four main phases which are Requirement Planning, User Design, Construction and Cutover. Generally, RAD approaches are more emphasizing on the development phases rather than planning tasks. It has a better quality of having users interact with developing prototypes of project functionality. Besides that, more activities can be done and completed on time of the expected budget. It can reduce the catastrophic failures of focusing on the development of incremental besides more analysis can be discovered and acted upon earlier in the process.

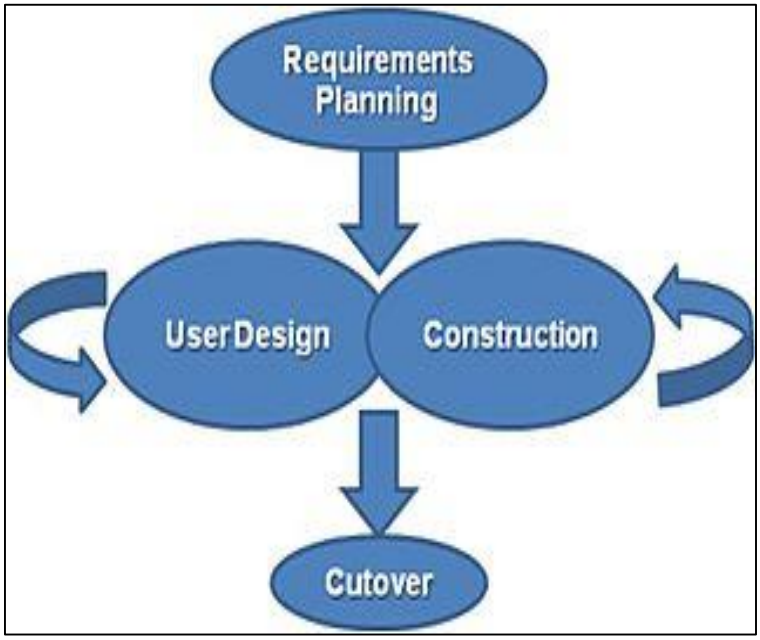


Figure 28: Rapid Application Development phases

3.1.1 Requirement planning phase

During the requirement planning phase, all the important information and theory about Augmented Reality was gathered. The theory is containing about the concept, hardware and software and the types of AR with the applications that been applied in the many field areas. These parts are defined as Chapter 2 which is Literature Review. Moreover, the problem statement of the project (Section 1.2), the objectives (Section 1.3) and the significant and relevancy of the project (Section 1.4) also clearly stated. This is very important to ensure that the project will be achieved the objectives as planned.

Since the project is developed and targeted for 3 to 6-years-old children, the planning is required to gather information on understanding the children's learning process of colour, the current problems and the enhancement of implementing augmented reality of digital storybook with mobile application. The information was collected from the distributive survey questionnaires. It was used to get the parents and teachers point of view on the children learning about colour. The template for the questionnaires is attached to Chapter 4, Result and Finding. Besides that, the researches on journals, articles and other research papers also been studied to collect the correlated information to the project development as the supportive materials. The existing products of the market also are viewed as the reference to start the project and the future improvement.

3.1.2 User design phase

Designing phase is the longest period throughout the prototype development cycle, whereby the designing stages, build the design functions and operations were described in details. It is including the designing the storyboard, outline, diagrams and also the interfaces. Regarding the storybook, the early design was based on the specifically designed storyboard as in Section 3.4.1 below.

During the Final Year Project II (FYPII) period, some changes were made in terms of the storyline as well as the book designs. Due to the time constraints, only one storyline which is The Ninja was selected instead of two as early planned. The

storybook and the background images were designed by using Storyjumper, a website pages that provide the templates and tools to design storybooks. The sample of storybook is attached to Section 3.3.2 below. Therefore, the user designs phase activity become easier and save time. In the meantime, the images that will be used as AR marker was designed by using Adobe Photoshop. Indeed, these software and tools were really helped during the user design phase activity.

3.1.3 Construction phase

During the construction phase, each prototype iteration was built, was based on the system analysis and design set earlier. This is included the interfaces of the mobile app, the storyline of storybook and development of augmented reality such as the 3D modelling part and code the programming. The modelling part is using the Blender software and it took about three to four weeks to finish the characters models. The creation of the characters is included of modelling, texturing, rigging and animating the models that were very challenging and taught activity. Then, the integration and compilation was done by using Unity 3D which is the cross platform game engine with a built-in integrated development environment (IDE). It is used to compile the characters models with animation, programs and SDKs to design the application. It is then checked to guarantee and ensure the functionality developed is achieved the user requirements. Some changes and modification are done in order to make sure the users are completely satisfied with the product. The phase involves developing the AR application using the Vuforia SDK and Unity 3D. The snapshot of the modelling process of characters models also was shown as Section 3.3.3 below.

3.1.4 Cutover phase

The final phase in RAD approach is cutover phases or known as implementation stages. This phase only can be done after the testing has been completed therefore the software can be installed in a “live” environment and launched. The complete integration is including the implementation of AR mobile application of colour storybook.

Other than that, the usability tests were carried out to ensure, whether the system meets the requirements established earlier or not. The frequent testing and iterating of the process, until reaching a satisfactory outcome, ensured that final users can use the product easily with no faults or errors.

3.2 Tools Development

The tools that have been used can be categorized into two main categories, software and hardware.

3.2.1 Hardware and Equipment

The project is using a Windows 8 operating system with an Intel Inside processor. It can also ensure the smoothness and fast real time of rendering the 3D models design before building and installing to the Android device for incremental testing. Furthermore, the webcam was used for dynamic testing for new features, before building and deploying to the android device for incremental testing.

3.2.2 Software, Platform and SDKs

Blender

Blender is an open-source 3D computer graphics software product used for creating animated films, visual effects, art, 3D printed models, interactive 3D applications and video games. Blender's features include 3D modelling, UV unwrapping, texturing, rigging and skinning, rendering, video editing and compositing. Alongside the modelling features it also has an integrated game engine.

Android SDK

The Android software development kit (SDK) is the development kit to help develop android applications that include a comprehensive set of development tools. These include a debugger, libraries, a handset emulator based on QEMU and documentation. The Android SDK was used to compile and deploy the application, to be used on a mobile phone.

Vuforia SDK

Vuforia is an Augmented Reality Software Development Kit (SDK) for mobile devices that enable the creation of Augmented Reality applications. It uses Computer Vision technology to recognize and track planar images.

Adobe Photoshop

Adobe Photoshop is a graphics-editing program. That was used to edit and create, the logo, buttons for interactions and finally the marker-less marker especially for the colour storybook.

Unity 3D

Unity 3D is a cross-platform game engine with a built-in integrated development environment (IDE) developed by Unity Technologies. It is used to develop video games for web plugins, desktop platforms, consoles and mobile devices. The powerful Unity 3D is used to compile all the above list of software, programs and SDKs, to design the application. In this project it is useful for creating the AR application that integrates with the 3D models created using Autodesk Maya.

3.3 Project Activities

3.3.1 Mobile Application

The initial interfaces designs for mobile application are as following:

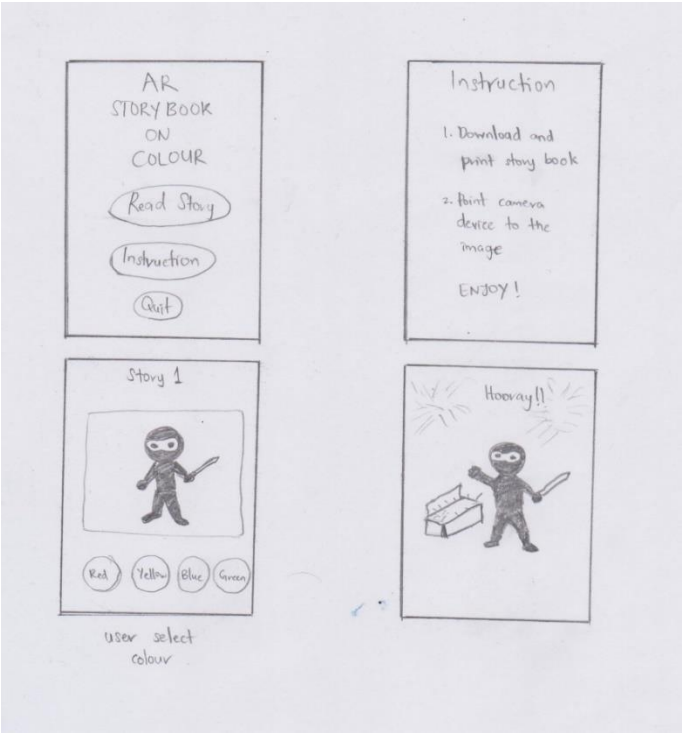


Figure 29: Initial interfaces design

The final designs are sticking to a simple yet efficient design, which has a proper contrast graph and most of the markers for the final designs contain more than 3 stars, hence, efficient flow in performance. The figures below are the sample of the finalized design of mobile application interfaces.

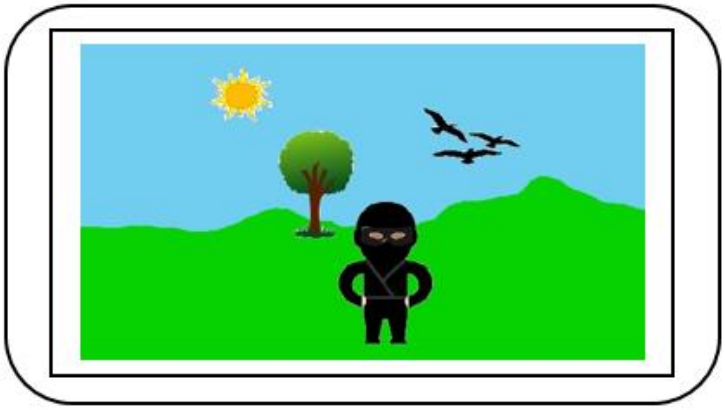


Figure 30: Sample of mobile application design

Figure 31: Sample of mobile application design

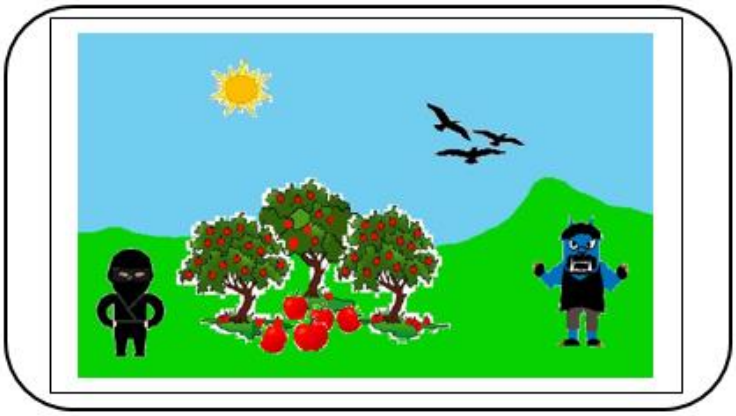


Figure 32: Sample of mobile application design

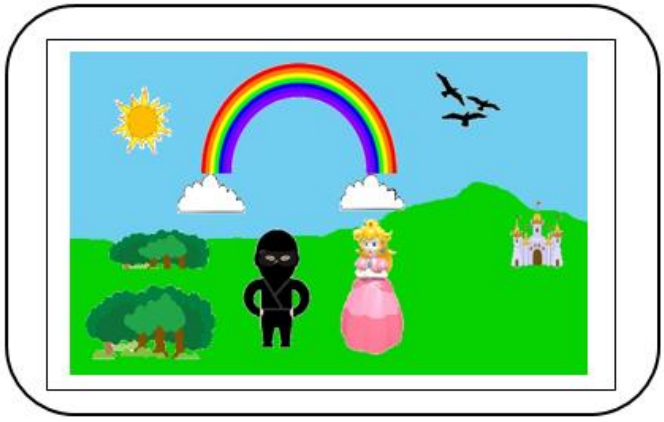


Figure 33: Sample of mobile application design

3.3.2 Storybook Design

For the design of the colour storybook, it has been done by in Storyjumper, a website page that provides the templates and tools to design storybooks. The screenshots of the storybook design are shown below.

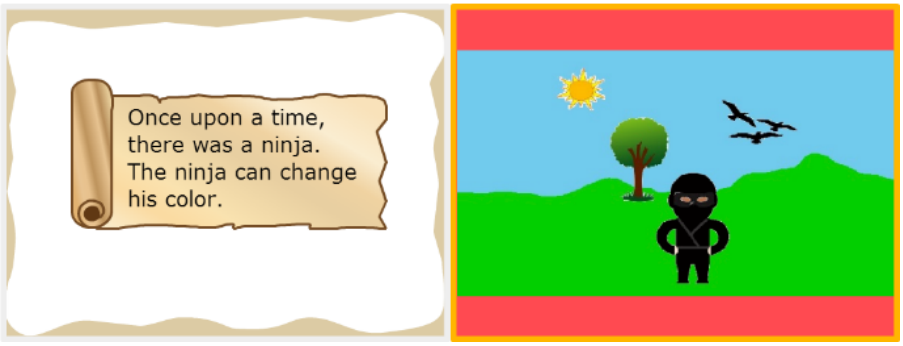


Figure 34: Screenshot of the storybook design

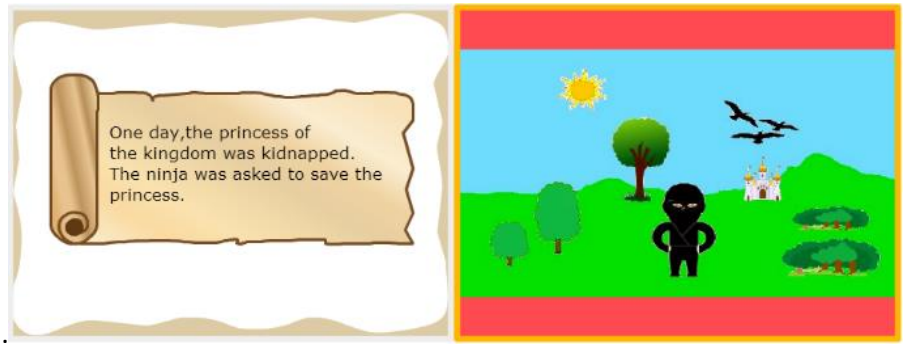


Figure 35: Screenshot of the storybook design

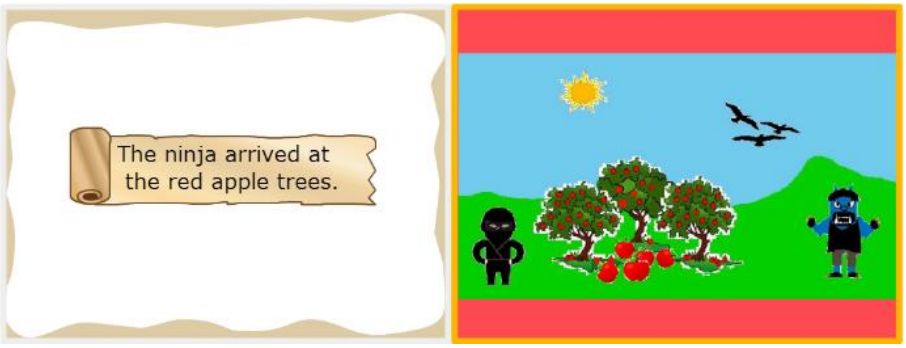


Figure 36; Screenshot of the storybook design

Figure 37: Screenshot of the storybook design

3.3.3 Model Development

3D Modelling

As the project is augmented reality, whereby the 3D models are appearing whenever the camera devices are pointing to the AR storybook images, therefore it is important to create the 3D models. Thus, the Blender software is the good platform top create the 3D models. As an example, the figure below shows the ninja model that was modelled by using Blender software.

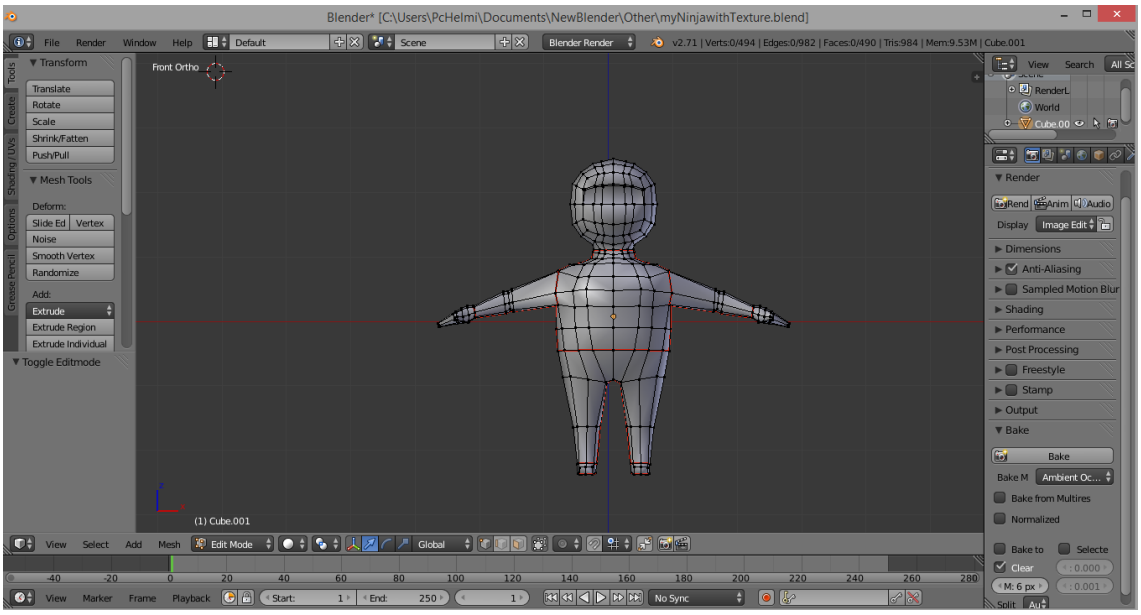


Figure 38: Sample of 3D modelling

3D Rigging

3D rigging in another word is skeletal animation, which is the technique in computer animation in which a character is represented in two parts: a surface representation used to draw the character (called skin or mesh) and a hierarchical set of interconnected bones (called the skeleton or rig) used to animate (pose and key frame) the mesh. Below is the example figure of rigging of the ninja model whereby bones are made to control the model for animation.

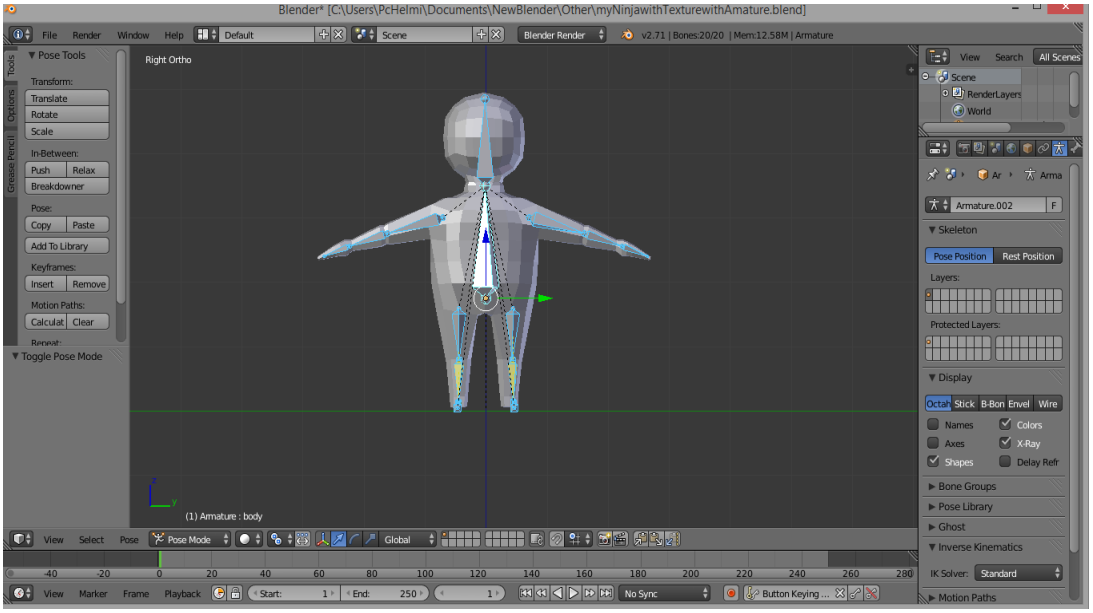


Figure 39: Sample of 3D rigging

3D Animation

Animation phase is very important to create the animation clips for enabling the models to make movements. Once the animation models were created, it can be directly imported to the Unity 3D. Generally, in this project the animation controller known as Mecanim in Unity 3D was used to edit the animation flow to ensure a proper and smooth animations after having set the animation key frames. Figure below shows the 3D models animation created in Blender software.

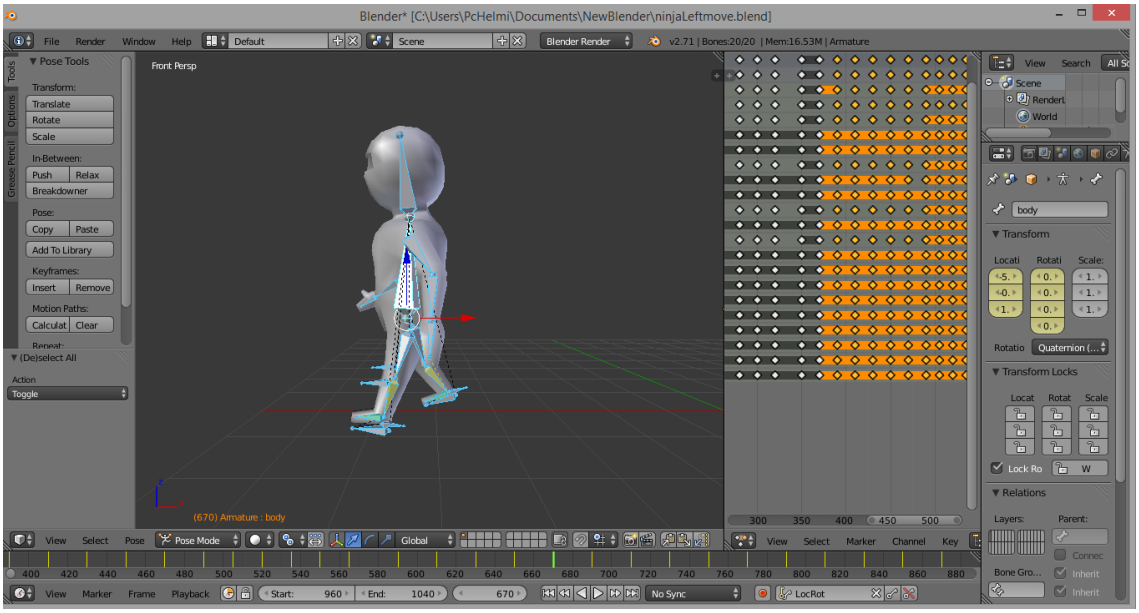


Figure 40: Sample of 3D animation

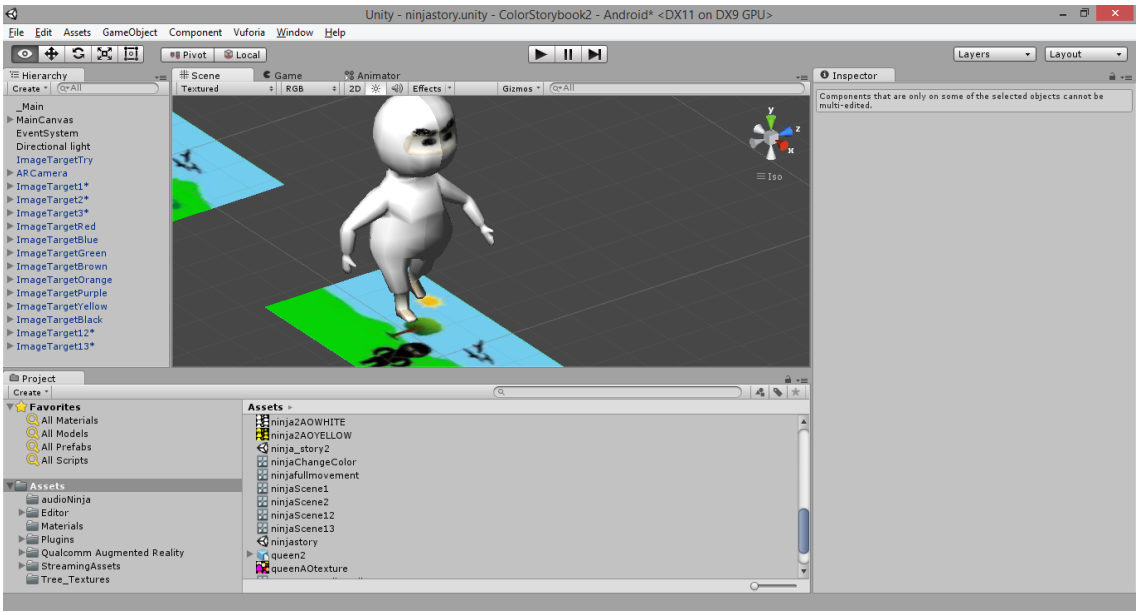


Figure 41: Example of model in Unity3D

3.4 System Architecture

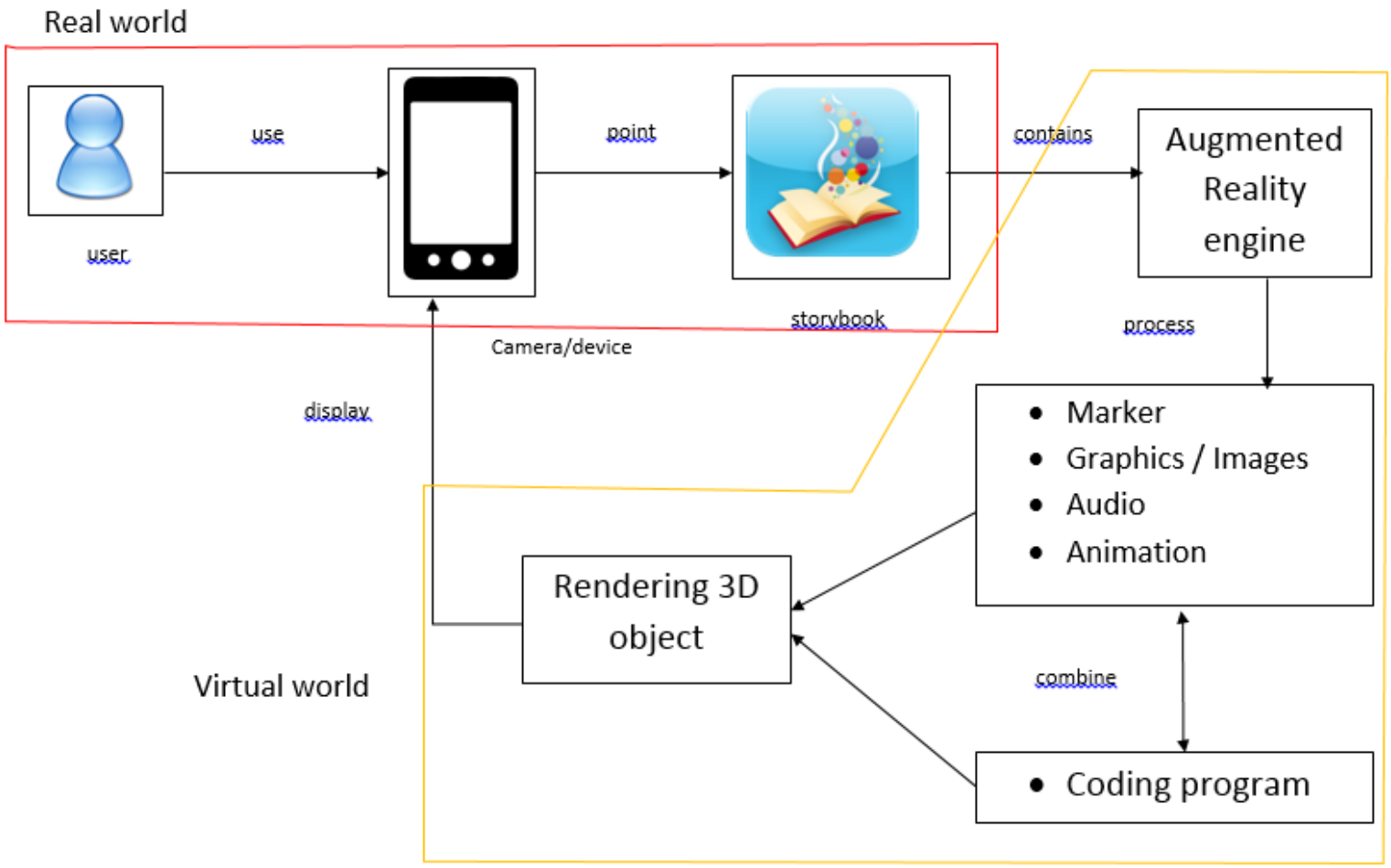


FIGURE 42: SYSTEM ARCHITECTURE OF PROJECT

Figure below shows the procedure steps of using the AR mobile app. These procedures are need to be follow in sequence in order to get the app functions.

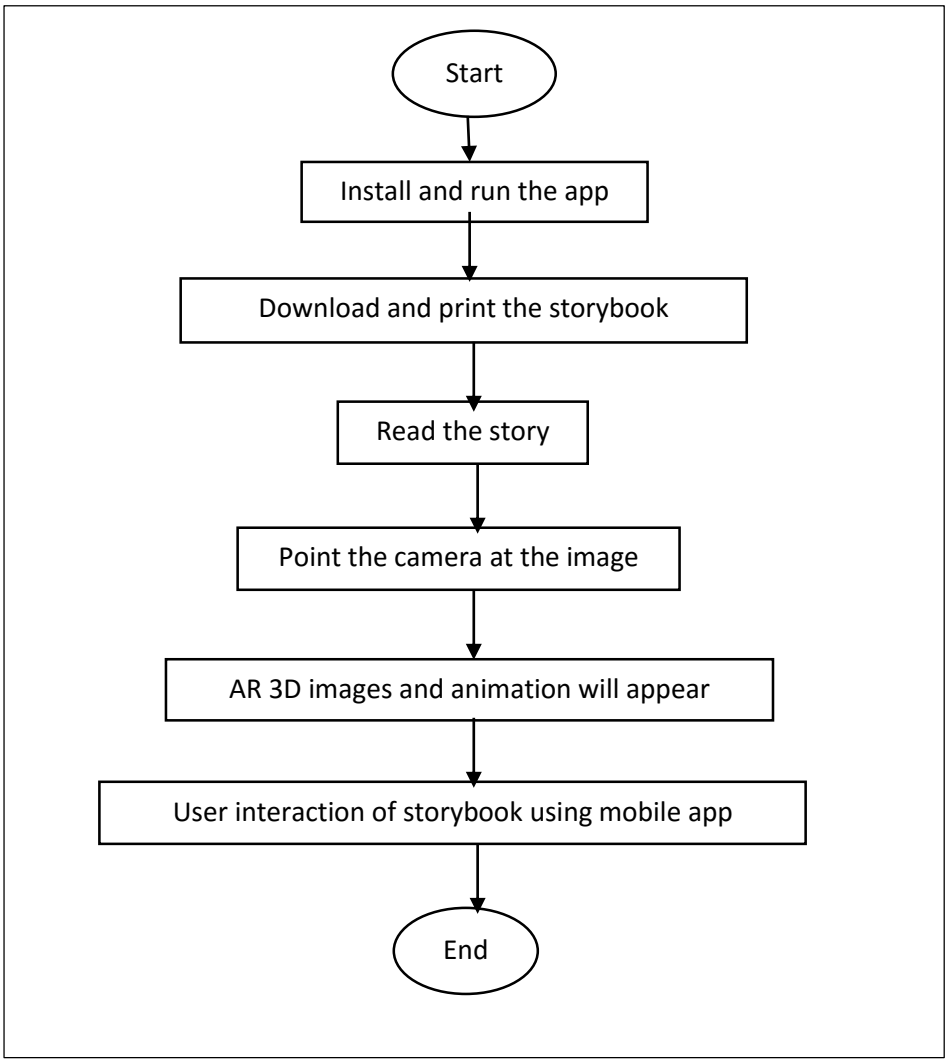


Figure 43: Procedure of project

Flowchart of Interacting AR mobile application with the storybook

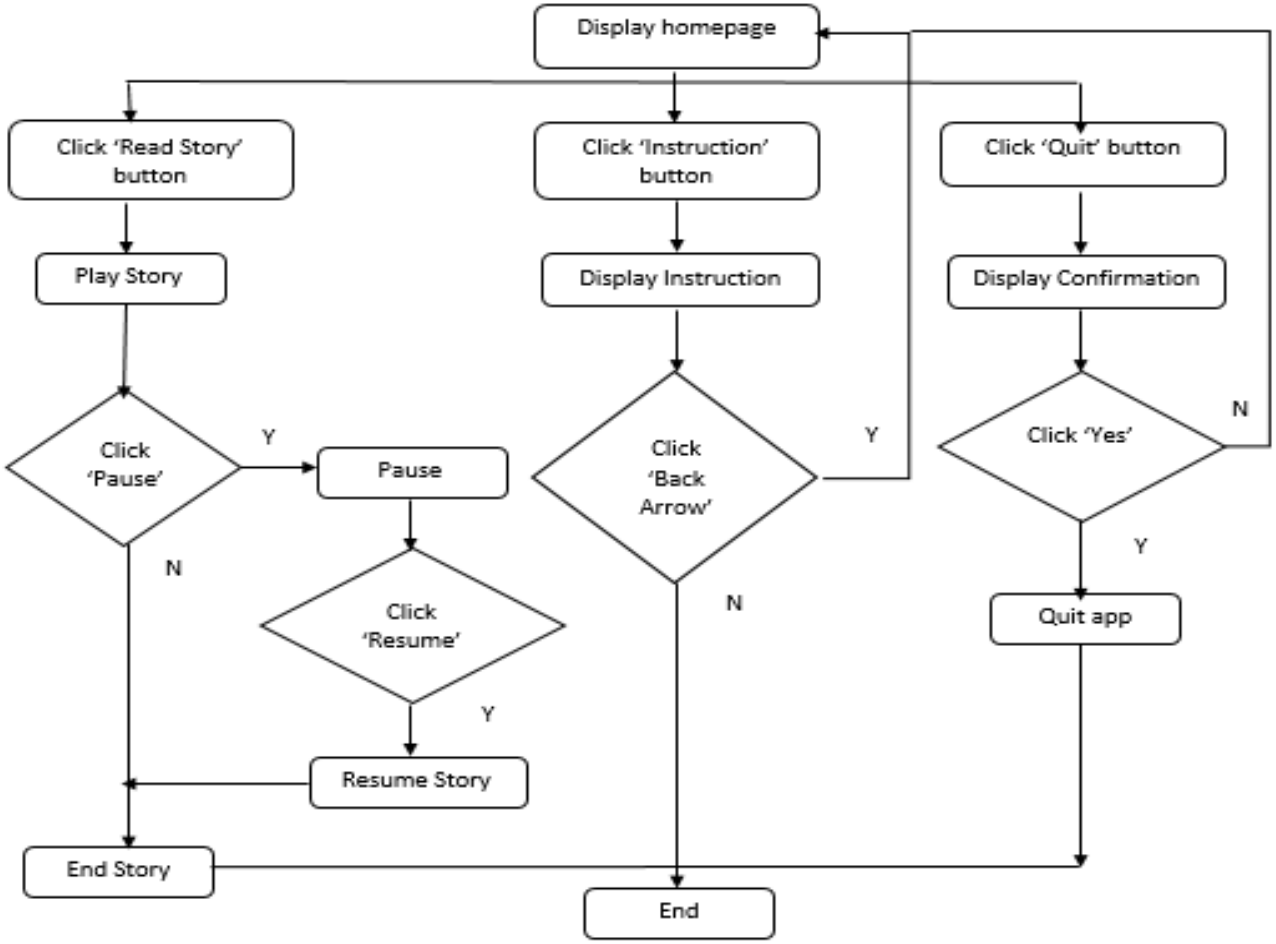


Figure 44: Flowchart of AR mobile app using storybook

Use case diagram for AR mobile app for children learning on colour.

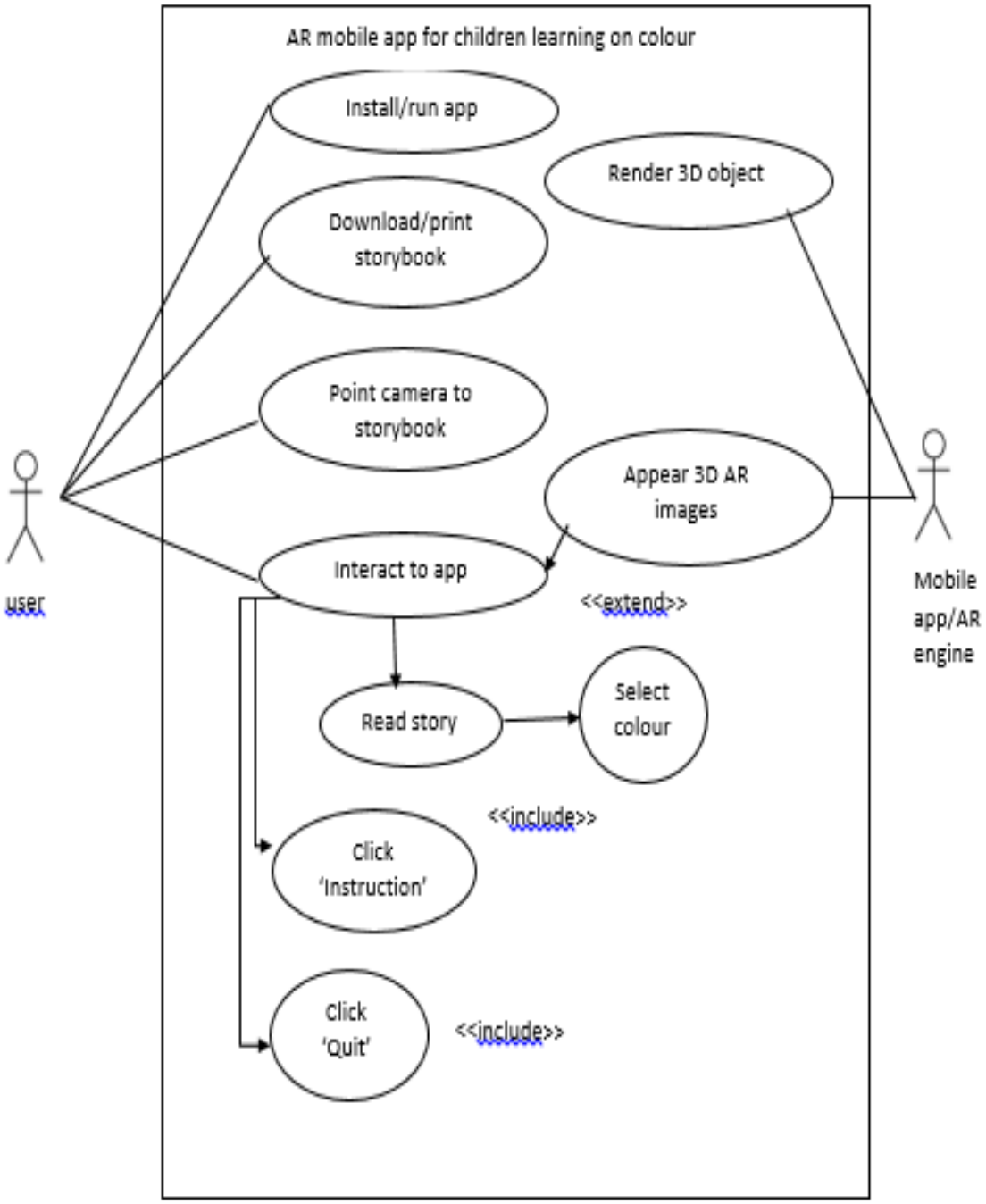


Figure 45: Use case of the project

3.5 Challenges Encountered

In general as mentioned, earlier the methodology used is rapid application development, each iteration would produce a working prototype. Consequently, the problems and challenges have occurred.

3.5.1 Program Installation, Compilation & Learning Curve

One of the earliest problems was dealing with a few amounts of software, SDKs and environment variables to install. For example, the Android SDK installation and it's computability with the Unity 3D version. Other issues were learning the Unity3D environment, and its components and functions, also learning the Vuforia sdk and use it with the unity-scripting library all combined in unity, which is also took a lot of time.

3.5.2 Model Development

In terms of model creation, there was some challenges that have been encountered, whereby to fulfill the interaction and animation objectives. For example, the 3D models are several times were changed and modified to be properly work in Unity 3D. The other challenges are realized as the 3D models in Blender software were not centred at the origin point that cause unexpected position while integrating into Unity 3D.

3.5.3 Time Constrain

A project with the development of 3D models really needs more time to create, rig and animate as well. Besides that, the time allocation needsto be required to design the storybook, and also the mobile development interfaces. Fortunately, the prototype has met all requirements, due to proper time management and constant work.

3.6 Methods of Survey and Observation

3.6.1 Questionnaires Survey

For gathering the information and user requirements, the survey and observation has been done among the parents, teachers and the children itself. Parents have been distributed the questionnaires survey form which consists of their personal information and questions relating to their perceptions and responses to the current children

learning. The overview of this project also was introduced and their feedback are kept for the analysis purposes. Basically, the purpose of the questionnaires is to determine the sensitivity among parents on the children learning besides collecting their feedback and opinion on this technology invention. The sample of questionnaires as the following below:

1. Do your children own a personal smartphones/tablets/ipad? (*Adakah anak anda memiliki telefon pintar/ tablet/ ipad peribadi?*)

   □ Yes (*Ya*) □ No (*Tidak*)

2. Have you install or download any learning mobile applications for your children? (*Adakah anda memasang atau memuat turun sebarang applikasi telefon pembelajaran untuk anak anda?*)

   □ Yes (*Ya*) □ No (*Tidak*) □ Not sure (*Tidak Pasti*)

3. How the way you teach children about colour? (*Bagaimana cara anda mengajar anak-anak tentang warna*)

   □ Using books (*menggunakan buku*)

   □ Theoretical way (pointing at the objects) (*Secara teori(menunjuk ke arah objek*)

   □ Using mobile app (*menggunakan applikasi telefon*)

   □ Others (*lain-lain*)

4. Do you prefer to teach your children using traditional (book) or technological (mobile applications)? (*Adakah anda lebih suka untuk mengajar anak-anak anda menggunakan tradisional (buku) atau teknologi (aplikasi mudah alih)*)

   □ Yes (Ya) □ No (Tidak) □ Not sure (Tidak Pasti)

5. Technologies nowadays are introduced 'augmented reality' whereby the user can view the object in 3D. Do you agree if the technology is applied in children's education so that will enhance children interesting and their understanding? (*Teknologi sekarang telah memperkenalkan 'augmented reality' di mana pengguna boleh melihat objek secara 3D. Adakah anda bersetuju jika teknologi itu diapplikasikan dalam pendidikan anak-anak bagi meningkatkan minat kanak-kanak dan pemahaman mereka?)*

   □ Yes (Ya) □ No (Tidak) □ Not sure (Tidak Pasti)

3.6.2 User Perception Survey

User perception study was conducted among parents that having 3 to 6 years old children and pre-school teachers. Before they fill up the survey form, they had tested AR mobile application. There are five questions had been asked to the users which regarding the usability of the AR-Alphabet product. Each question is scaled from 1 to 5 where 1 are for least agree and 5 are for most agree. The lists of questions asked are as below:

		1	2	3	4	5
1	The product can assist children learn colour.					
2	The product is fun and interactive.					
3	The product is easy to be used.					
4	Children would love to use the product to learn colour.					
5	I would buy the product.					

In addition, comment columns also prepared to enable users to drop some comments or any other suggestions to be added and implemented on the application.

3.6.3 Observation

Observation study is conducted while observing kids play the AR mobile application of colour. The observation study also aimed to analyse the children response of using the AR mobile application and to investigate the use of AR application for engaging the children on learning colours in terms of identifying colour, and determining of uses and functions of colours. The responses were used to assess usability and fun of AR mobile application.

3.7 Key Milestone and Gantt Chart

Gantt chart illustrates the start and finish dates of the activities of the projects. It comprises the work breakdown structure of the project. This project required almost more than three months or around 14 weeks to complete the process. The Gantt charts below shows the duration of the activities involved in this project from the selection of project topics and end with the proposal defence.

#Activity	Description/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
No 1	Selection of Project Topic														
1.1	Propose the title														
1.2	Looking for SV														
No 2	Preliminary Research Work														
2.1	Chapter 2: Literature Review														
2.2	Chapter 1: Introduction														
2.3	Chapter 3: Research Methodology														
No 3	Submission of Logbook														
No 4	Design project outcome														
No 5	Project work continues														
5.1	Chapter 4: Result and Discussion														
5.2	Chapter 5: Conclusion														
No 6	Submission of Interim Report														
No 7	Proposal Defence														

Table 2: Gantt chart of the final project year I

Planned Duration

Actual Duration

#Activity	Description/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Project Work Continues														
2	Submission of Progress Report														
3	Project Work Continues														
4	Pre-SEDEX														
5	Submission of Technical Paper														
6	Submission of Dissertation (soft bound)														
7	Oral Presentation														
8	Submission of Project Dissertation (Hard Bound)														

Table 3: Gantt chart of the final project year II

4.0 Result and Discussion

4.1 Analysis of Survey Result

The questionnaires survey and user perception survey method has been conducted among the parents and pre-schooler teachers. The questionnaires survey was distributed directly to several numbers of parents especially who are having about 3 to 6 years old children. Meanwhile, the user perception survey also was done to the pre-schooler teachers at the preschool nearby Universiti Teknologi PETRONAS. Generally, both of these requirements gathering processes are intended to determine the sensitivity and their concern on the children learning on colour besides collecting their feedback and opinion on this technology invention. The result helps to support the developed application for further improvement and alteration to the application.

The questionnaires survey was conducted to five parents that having young children. Mainly, the questionnaires have eight questions that associated with the children learning and also about colour. In the user perception survey, five questions were asked to users. The survey involved of eight respondents that involved three pre-school teachers and five parents. Each question is scaled from 1 to 5 at which are 1 is for the least agree and 5 is for the most agree. The graphs and pie charts below shows the summarization and description of questions that were asked.

4.1.1 The questionnaires survey for parents

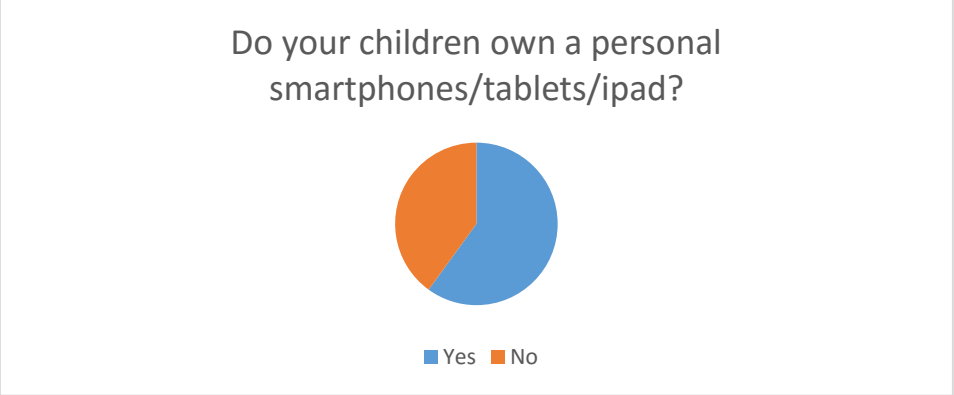


Figure 46: Pie chart for question 1

Regarding the chart above, it shows parents todays are desire to provide their children with at least one gadget or smartphone. It really shows that the children's generation nowadays are surrounded with gadgets and technologies.

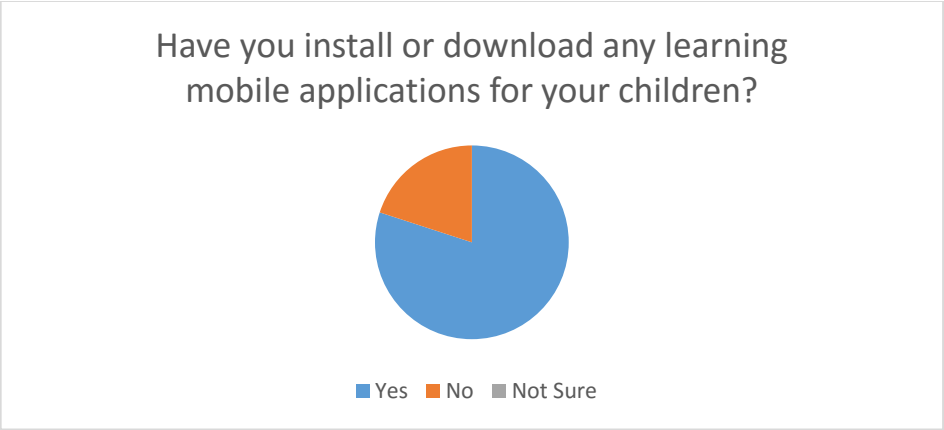


Figure 47: Pie chart for question 1

Based on first two pie charts, it show most of the parents provide the smartphone to the children and most of them really taking care on the children learning. The rest are assume that the smartphone or gadget is for their children to release tension.

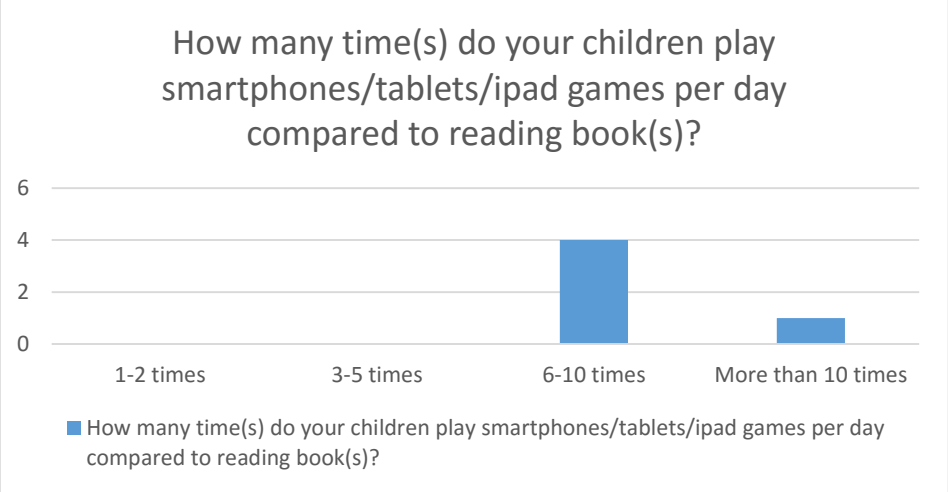


Figure 48: Graph chart for question 3

The figure above stated that most of the parents agreed that their children spend more time on smartphone or gadgets especially for playing games compared to read books. Based on this information, it was a good sign for implementing the AR mobile app project as children nowadays are the smartphone and gadgets users.

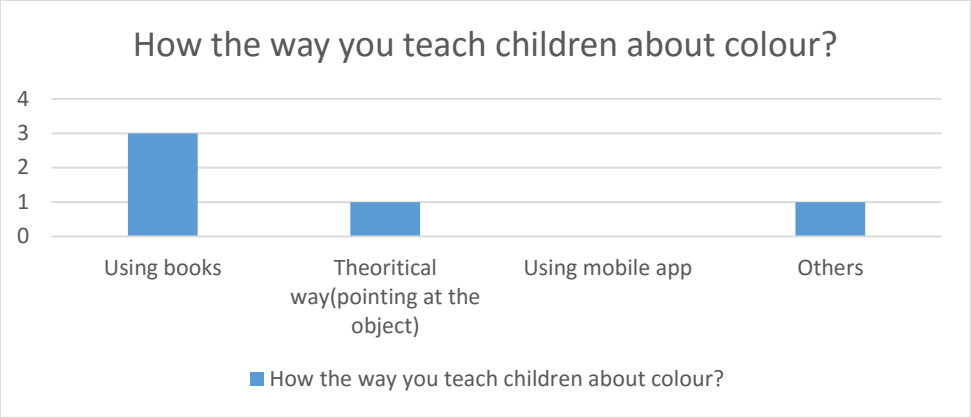


Figure 49: Graph chart for question 4

Most of the parents mentioned that they used physical books as the way to teach their children on colour. Only two of them stated different which are by teach theoretically and exposed colours during watching television.

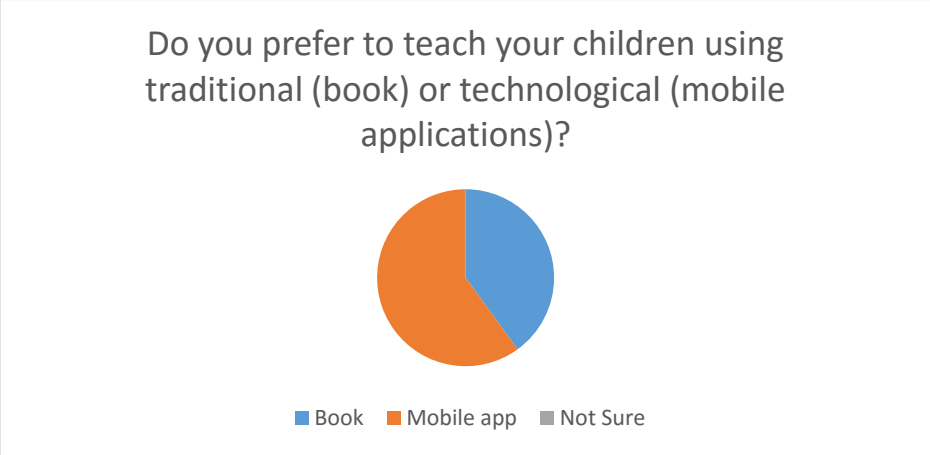


Figure 50: Pie chart for question 5

The figure above stated that most of the parents prefer to teach colours to their children by using mobile app since they provides smartphone to them. However, there are some parents still prefer to use book because they assume it is more efficient and easy to learn.

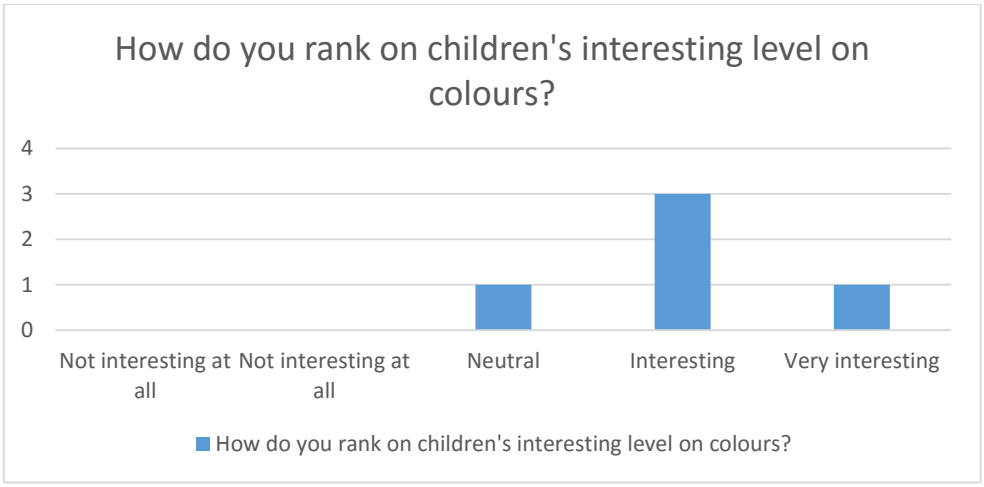


Figure 51: Graph chart for question 6

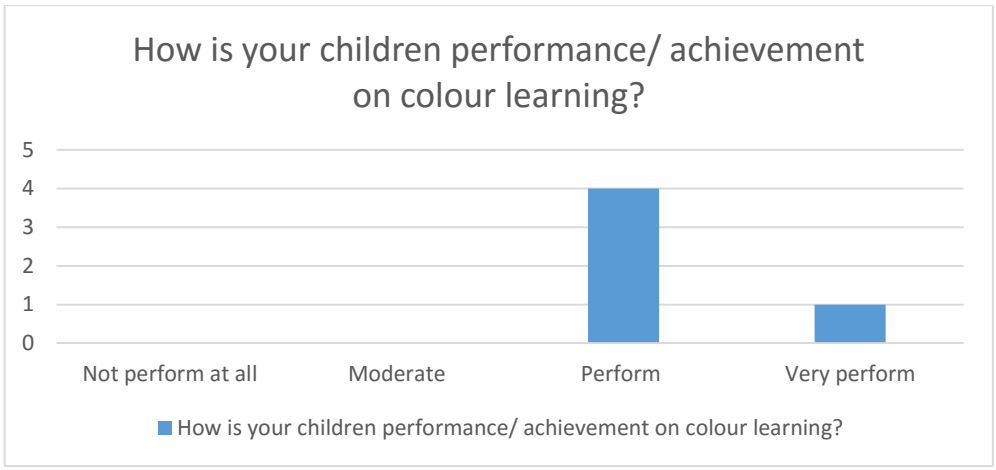


Figure 52: Graph chart for question 7

Referring on graph chart 6 and 7, parents believe that their children have their own interesting on colours especially when choosing toy stuffs and clothes. Based on the performance, they also trust that their children have a good performance on learning colours because it is a children nature.

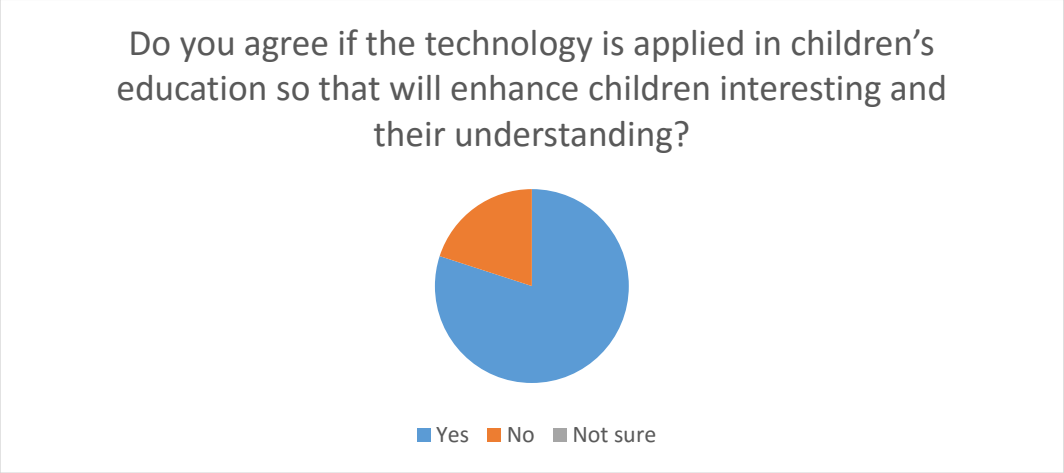


Figure 53: Pie chart for question 8

Figure 53 shows the graph on last question asked which are either parents agree or not if the augmented reality technology is applied to mobile app especially for children education. The parents have described a bit about the augmented reality and their functions. The feedback given was positive as they stated that the technology should be improves correspondingly to the times and generations. Only few of them still remain on the theoretical way which is by using physical books because easy and can learn practically about colour.

4.2 User Testing Results

4.2.1 The user perception survey result

User testing study is divided into two which user perception studies that involved pre-school teachers and parents with small kids as well as observation study which involved the pre-school children of age 3 to 6 years old. The result helps to support the developed application for further improvement and alteration to the application.

In the user perception survey, five questions asked to users. The survey involved eight respondents. Each question is scaled from 1 to 5 at which are 1 is the least agree and 5 is for the most agree.

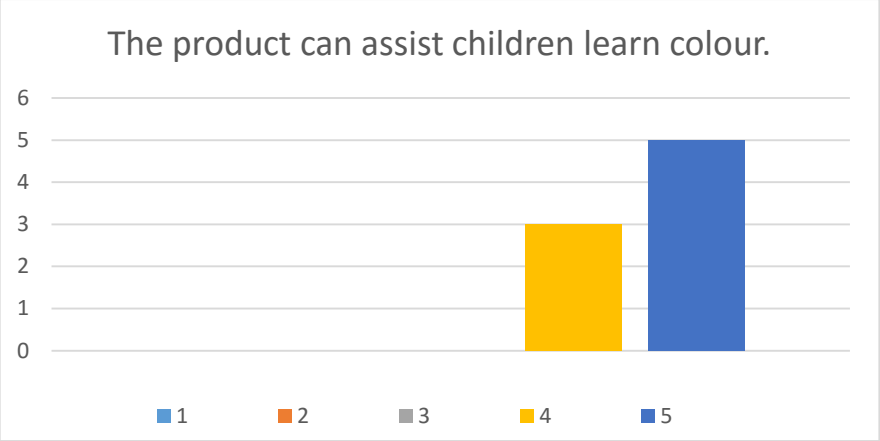


FIGURE 54: BAR CHART OF QUESTION 1 OF USER PERCEPTION SURVEY

The figure above shows the graph conducted for the first question. The users were asked on their perception either the product can assist children learn colour. Results have shown that majority of respondents rated with scale 5. This shows that the respondents agreed that the product can assist children on colour learning.

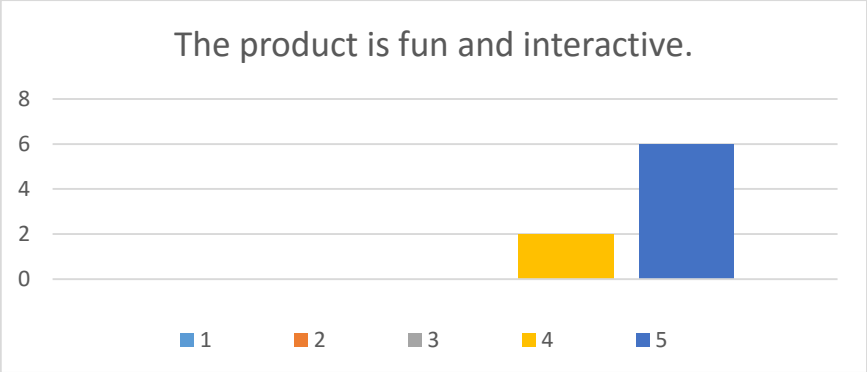


FIGURE 55: BAR CHART OF QUESTION 2 OF USER PERCEPTION SURVEY

The figure above displays the graph on respondent's rate on the enjoyment and interactivity of the product. Results have shown that majority 6 of the respondents rated scale 5 while another 2 rated scale 4. This shows that most of the respondents agree that the product is fun and interactive.

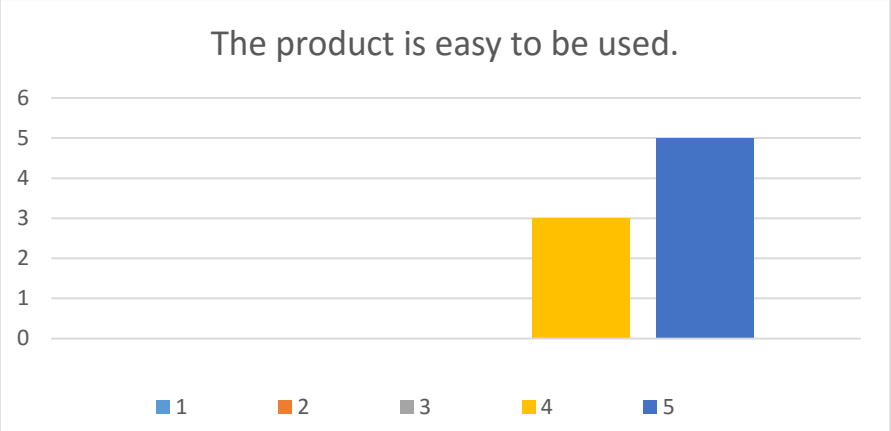


FIGURE 56: BAR CHART OF QUESTION 3 OF USER PERCEPTION SURVEY

The figure above displays the graph on respondent's rate on the acceptance and easiness to use the product. Result has shown that majority 5 of the respondents rated scale 5 while another 3 rated scale 4. This shows that most of the respondents agree that the product is easy to be used.

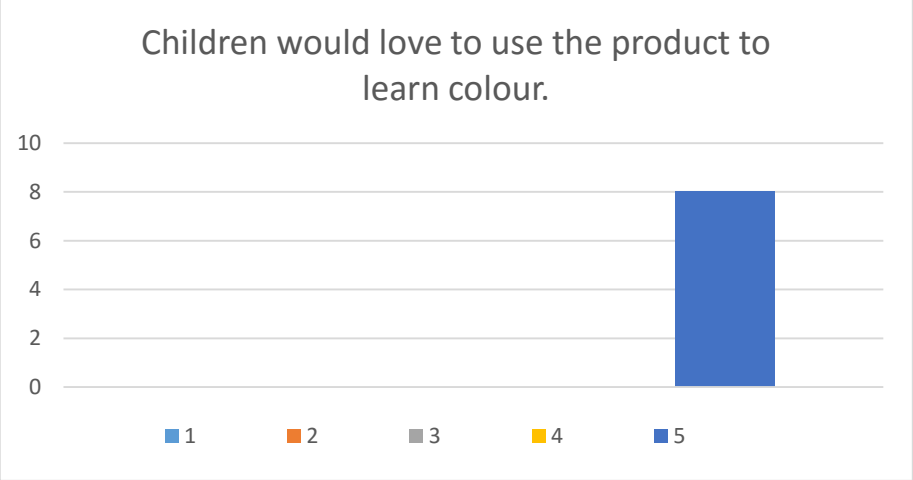


FIGURE 57: BAR CHART OF QUESTION 4 OF USER PERCEPTION SURVEY

Figure above shows the graph on four question asked the teacher's perception on either kids would love to use this product. The graph shows that all of the respondents agreed that children would love to use the product to learn colour by rating it for scale 5.

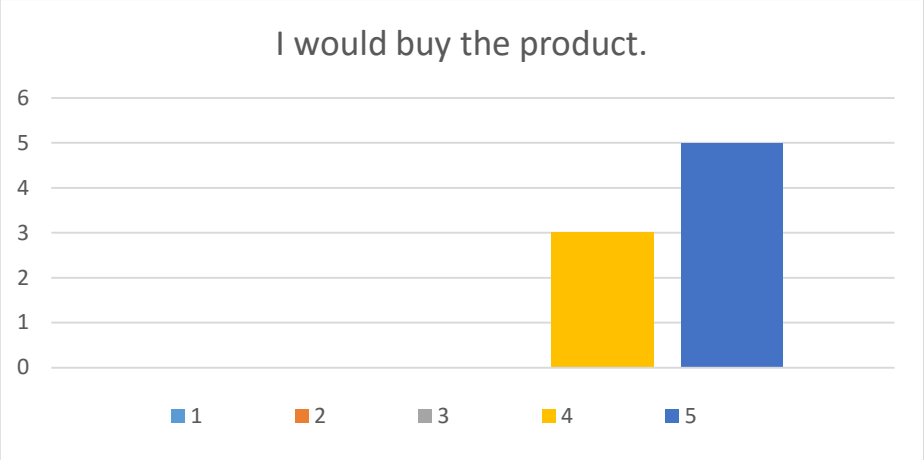


FIGURE 58: BAR CHART OF QUESTION 5 OF USER PERCEPTION SURVEY

Figure above shows the graph on last question asked which is either the respondents would buy the product for their children if the product available on markets. The graph shows that majority 5 of the respondents rated scale 5, which are most likely that they would purchase the product for kids, and the remaining 3 rated in scale 4, which are likely to purchase means still prefer to use the current method to learn colour. Overall of the survey results, which based on the five questions, asked shown positive feedback from the parents and teachers as all of the questions were rated at scale 4 and 5.

Observation study is conducted while observing children play the AR mobile application on colour. The observation study also aimed to analyse the children response of using the AR mobile application and to investigate the use of AR application for engaging the children on learning colours in terms of identifying colour, and determining of uses and functions of colours. Some questions were also asked to know their interest in colours and their enthusiasm for learning by using gadgets and technologies.

No	Question
1	Do you know about colour?
2	What is your favourite colour?
3	How many colours do you know?
4	Who teach you about colours?
5	How you know and learn the colour?
6	Do you like when your teacher teach about colour at school? Best or not?
7	Are you interesting to learn colour using technology and gadget (smartphone)?

Table 4: Sample of questions for children

The responses were used to assess usability and fun of AR mobile application. Most of them were surprised at first to see the 3D models were appeared on the mobile screen over the storybook. There are some other reactions and responses from the children as below:

- Others tried to hit the storybook where they thought the 3D models are there.
- They excited to use the AR mobile application
- "Wow, it's amazing."
- "Interesting!"
- "The model is moving, even not very nice, but still acceptable."
- "Wonderful book. How the 3D images can be existing?"

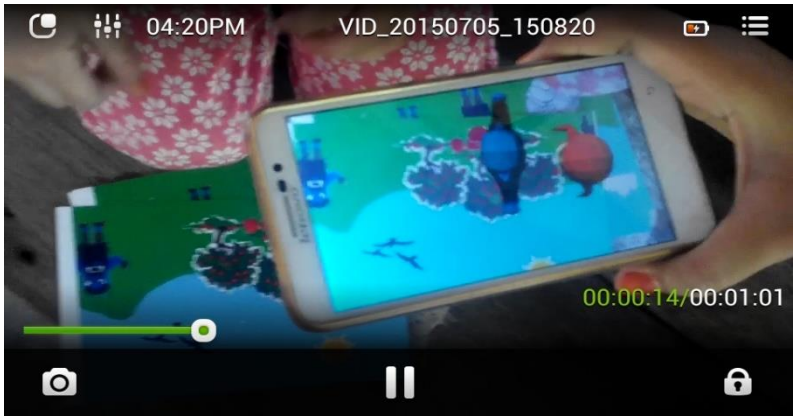


Figure 59: Snapshot of prototype video

In summary, the observation for this little prototype was successful and helped to know and prioritize the features that will be developed in the next phase of the project, which was the interaction and realistic animation.

4.3 Prototype

The prototype was divided into two parts, which are the storybook interfaces and the AR mobile application.

4.3.1 Storybook Design

The design of storybook interfaces has been shown in part 3.4.2. The interfaces are based on the storyline in the storybook. The story would has the animated 3D characters which have been applied the AR technology. The figures below are the samples of the storybook design.

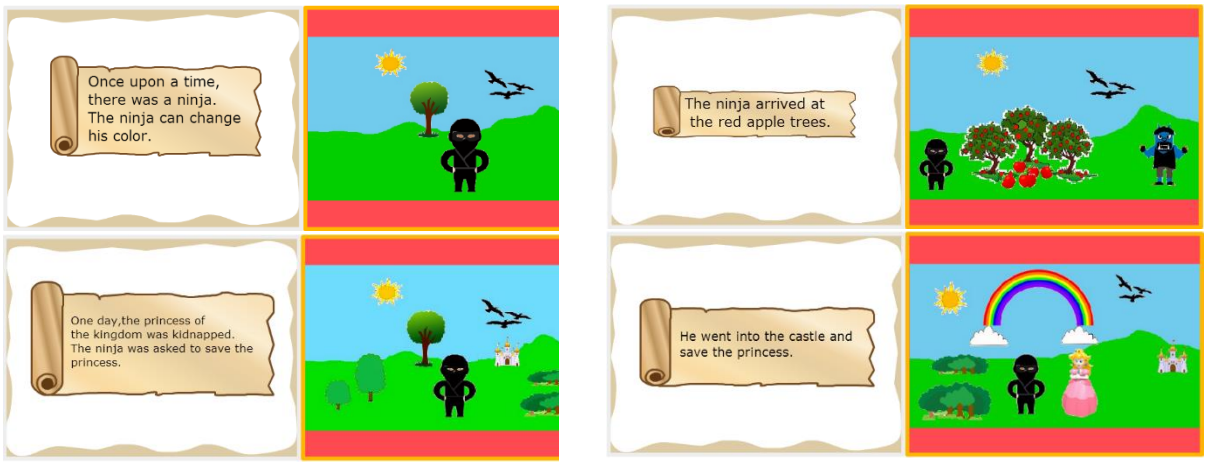


Figure 60: Sample of storybook interfaces design

4.3.2 AR Mobile Application

The application controls the device's camera, so that the according 3D images or models will be triggered when it pointed to the specific target image. The animated 3D models have been applied and integrated with the AR markers of the storybook by using Unity3D software. The 3D models would animate accordingly based on the storyline of the storybook. All the animations are controlled and altered by using the Mecanim Unity3D, which is the animator controller. The figures below show the snapshots of the finished AR mobile application.

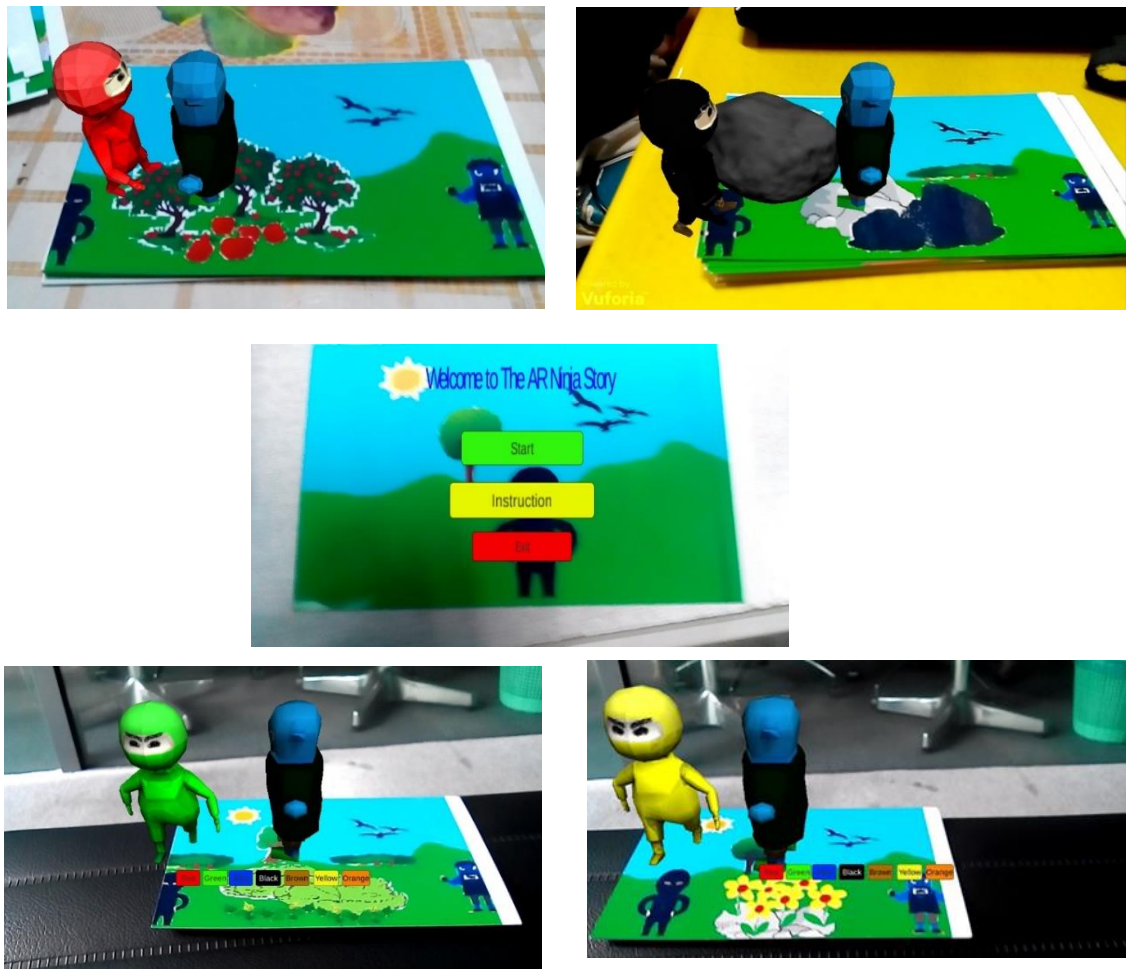


Figure 61: Snapshots of AR mobile application

As the information, the storybook is about a ninja who has a mission to save the kidnapped queen. Along his journey mission, he needs to avoid from being seen and arrested by the guards by disguising himself according to the coloured wall or his surroundings.

5.0 Conclusion and Recommendation

5.1 Conclusion

As a conclusion, the Augmented Reality mobile app for children learning education on colours is able to enhance the better understanding colours with the implication in real life. Other than that, children can learn in an interactive way besides more fun and interesting. Most of the learning way to teach colours is just manually pointing to the object and stating the colours by teachers or their parents. Therefore, the implementation of AR in mobile application would help the children on understanding, recognize and apply the colours in their life in fun and interactive way. By using the colourful physical storybook, they can know the storyline or otherwise they can just point the camera device to the images which is acts as the marker for better understanding storyline. The AR mobile app has attractive and interesting interfaces and 3D images where the users can work simultaneously with physical storybook and mobile app. Indeed, it will grab students or children's attention, creating more interesting and can stay focusing on their learning. To summarize, the project would probably become the better advancement of current manuals learning for teachers and parents to teach colours to their children. In the future, the project would be enhanced and improved to make it user-friendly and can fulfil some other considerations.

5.2 Recommendation

Based on the result and discussion in chapter 4, the respondents were preferred that AR should be implemented in children learning in such topics like colours because it is more interactive and can gain children's interesting on their learning. After taking all considerations and user requirements, the AR mobile app will be more interesting if it is includes of more interactive topics other than colours such as numbers and shapes. Furthermore, it will be even more interesting if the animations of the characters to be longer and do some more movements and positions. Other than that, it would be more fun and intellectual for users if it is including of interactive games and quizzes. Therefore, it would be more advanced features that can be implemented in the AR mobile application for the easiness of human daily life activities. One of the best

possibility of development is it can be applied on iOS application for expanding the use of the AR mobile app.

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