

ENGAGING LEARNING WITH
AUGMENTED REALITY FOR PRIMARY
SCHOOL SCIENCE EDUCATION

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ABSTRAK

Realiti Berperantara (AR) merupakan salah satu teknologi visualisasi yang semakin mendapat perhatian dalam semua bidang, terutamanya dalam bidang pendidikan. AR telah diaplikasikan di dalam bidang pendidikan untuk menghasilkan pengalaman pembelajaran yang unik. Pelajar di awal pendidikan cenderung untuk mengalami kesukaran dalam memahami konsep pembelajaran sains yang abstrak. Dengan memperkenalkan AR dalam bilik darjah, AR boleh berfungsi sebagai material yang berkesan untuk menambah kefahaman pelajar disebabkan oleh AR boleh menawarkan pembelajaran yang kaya dengan media. Oleh itu, tujuan projek ini adalah untuk membangunkan satu aplikasi AR Sains untuk pelajar sekolah rendah. Selain memaparkan setiap process yang berkenaan, pelajar juga dapat visualisasi konsep sains dalam process pembelajaran. Tiga aplikasi AR yang sedia ada dalam bidang pendidikan telah dikaji untuk menghasilkan versi aplikasi yang lebih baik. Model ADDIE telah dipilih untuk membangunkan aplikasi ini. Terdapat lima fasa yang terlibat dalam model ini untuk memastikan rekabentuk dan pembagunan aplikasi mencapai objektif yang dicadangkan. Aplikasi yang dibangunkan dinilai oleh guru dan pelajar sekolah rendah untuk menentukan keberkesanannya dan persepsi terhadap aplikasi tersebut. Dalam kaji selidik yang dijalankan mendapati pelajar memberikan reaksi yang positif dan bersetuju aplikasi ini mampu meningkatkan kefahaman mereka dalam subjek sains.

ABSTRACT

Augmented Reality (AR) is one of the visualization technologies that gradually gaining considerable attention in every field, especially in education area. AR have been applying in education field to create a unique learning experience. In early age of education, primary school students have trouble grasping and understanding the abstract science concept. By bringing the AR into the classroom, AR can serve as an effective tool to gain understanding since AR offer rich media learning. Therefore, the purpose of this project is to design and develop a Science AR application for primary school students. Besides displaying each process upon presentation of its corresponding marker, students can visualize the concept of science in process of learning. Three existing application of AR in the field of education has been review to produce a better version of application. ADDIE model has been chosen in development of this application. There were five phases involved in the model to make sure that the designing and developing of the application has achieves the proposed objective. The application was evaluated by the teacher and primary school students to investigate its effectiveness and user perception toward the application. The result showed that students give positive feedback and they agree this application can improved their understanding in science subject.

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LIST OF ABBREVIATIONS

AR	Augmented Reality
GB	Gigabyte
GPS	Global Positioning System
GUI	Graphical User Interface
IOS	Internetwork Operating System
LDD	Low Level Design
MB	Megabyte
OS	Operating System
SDLC	System Development Life Cycle
SDK	Software Development Kit
SLAM	Simultaneous Location and Mapping
STEM	Science Technology Education and Mathematics
TIMSS	Trends in International Mathematical Science Study
UAT	User Acceptance Test
UTP	Unit Test Plan
2D	Two dimension
3D	Three dimension

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Over the last two decades, Augmented Reality (AR) have been receiving attention. AR can be defined as a human machine interaction tools for computer generated an information to the real world environment. AR is an innovative technology that able to supplement a real world environment with computer to generated sensory inputs. These virtual component seem to coexist with the real one in the same spaces, enhances the user perception of reality and enriching the information. The AR technologies has been firstly used for the training pilots in year 1990s and have been start used in CAD programs for education in learning process, military, medicine, engineering design, robotic, telerobotic, manufacturing, maintenance and repair applications, consumer design, psychological treatments, etc. (Azuma & Behringer., 2001).

AR have been applying in education field to create a unique educational learning. According to the 2016 Horizon Reports, AR with its information over 3-Dimensional (3D) spaces can create a new experienced and recommended that AR technologies should be applied to bring new opportunities for teaching, learning technique, research and creative inquiry (Becker et al., 2016). Following the trend of technology development today, a few educational studies aim to examine what role AR, a technique of blending virtual information with real environment in real time (Cheng, 2017). AR has been touted as one of the most attractive technologies for education, being powerful and motivating tool which involve combination of sound, sight and touch (Cascales, Laguna, Pérez-López, Perona, & Contero, 2012). For the generation that raised in interactive technologies, bringing AR technology into

classroom is effective in maintaining a high level of motivation and engagement among student (JessicaWenke, 2016).

Learning experience is important in teaching and learning process for primary education due to student in age 7 – 12 need to gain more attention to increase motivation and satisfaction in classroom (Pérez-López & Contero, 2013). In this project, an AR application for educational purposes, more specifically in Science education for primary school are developed. This application has potential to grab attention for the students in learning process. It also potential to engage and motivate learners to explore material from different perspectives. It allows the demonstration of spatial relationships and the interactions of elements within a 3D space. Student can easily understand on what they are learning with the real experiences.

1.2 PROBLEM STATEMENTS

With enhancement in education, traditional ways of education are not efficient. The process of teaching and learning in primary school used conventional method such as using chalk to write, textbook and graphic to explain (Perlis, 2018). Textbook play a traditional role in science classroom (Ding, 2014). Teachers used a textbook only to help student read the topic being taught. But textbook reading only is not enough to encourage students learn well. Students need to imagines themselves in real world environment of the chapter they studying. A study revealed that many students disagrees with the methods of teaching that only focused on the textbook. It was found that many teachers focused on memorizing rather than making student to understand (Rasmy, Selvadurai, & Sulehan, 2017). Teacher not only need to find the research-based problems suitable for their classes but also need pedagogical support in implement the problems (Virtanen, 2014). With AR application, most student able to remember and retain the knowledge in the topic that were taught (Rasalingam, Muniandy, & Rasalingam, 2014).

According to the survey conducted in 2017, it revealed that the number of students enrol in STEM (Science, Technology, Education and Mathematics) subjects are declining. Asean Academy of Engineering and Technology honorary president

Datuk Hong Lee Pee said the number of students taking pure science classes are now less than 21% compared with 50% in the past (Nation, 2017). The teacher said that, most students are not naturally interest in STEM (Madeline Will, 2017). Due to this phenomena the result in science subject was decline. According to study reported in TIMSS (Trends in International Mathematical Science Study) result from 1999 (before PPSMI was introduced) to 2015 (after PPSMI ended), declined drastically compared with other countries. Although students' Science achievement in PISA (Programme for International Student Assessment) rose from 53rd place in 2012 (421) to 48th place in 2015 (443) and, in Mathematics, rose from 52nd place in 2012 (420) to 46th place in 2015 (446), it is still below the international average in the teaching of Science and Mathematics (Madeline Will, 2017).

In early age of education, students are difficult in understanding the concept of science especially in learning the nature of conceptual of science process (Srisawasdi & Wangsomnuk, 2015). In science curriculum, the water cycle, Photosynthesis and butterfly life cycle concepts are the topics that were first introduce in primary education and further until secondary education. These topics has been raises a number challenges in learning and teaching process due to its conceptual difficulty, leading lack of interest and misconceptions among students. Students are difficult in visualising the process, or relating it to things they can see (Russell, Netherwood, & Robinson, 2015). With AR technology, students can visualize the process by combining virtual information with real world information that can provide users with access to rich and meaningful multimedia content (Srisawasdi & Wangsomnuk, 2015). Table 1.1 shows the summary of problems that faced by student in sciences education.

Table 1.1 Summary of problems faced by students in science's education

No	Problem	Description	Effect
1	Traditional ways of education are not efficient	The process of learning and teaching using traditional method such as chalk and talk are not effective. Teacher are more focus on textbook only to make student remember rather than make them understand.	Students have difficulty in understanding on what they are learning in class.
2	Student are not interested in science subject	The number of student taking STEM subjects was decrease due to lack of interest and the result in science subject was declined.	The TIMSS result declined drastically compared with other countries.
3	Some topic in science education are difficult to understand by students.	The process of water cycle, photosynthesis and life cycle of butterfly contains interrelated conceptual components and one of the challenging topic to learn.	Student often misconceptions of the topic and have lack of interest due to the difficulty to understand the concept process without visualizing the dynamic process and their mechanism.

1.3 OBJECTIVE

Based on the problem statements, the objectives of the project are:

- i) To study the existing Augmented Reality (AR) applications in primary school science education.
- ii) To design and develop an Augmented Reality (AR) application for primary school science education.
- iii) To evaluate the effectiveness and functionality of the developed Augmented Reality application for primary school science education.

1.4 SCOPE

The scope of the project are:

User Scope:

- i) Students in age 10 – 12 years old.
- ii) Students study in area Gambang.

System Scope:

- i) Covered photosynthesis process, water cycle process, life cycle of butterfly only.
- ii) Covered topic in subject science only.

Development Scope:

- i) Contains multimedia elements such as 3D models animation, graphics, sound and text.
- ii) Using Adobe Photoshop, Autodesk Maya, Unity Software.

1.5 SIGNIFICANT

i) Children / Students

Students can have a process of learning in an interactive ways and gain better understanding. They can learn science subject in fun ways and can enhanced the real experience in class.

ii) Teachers

Teachers can implement a new way to teach in the class to create the engagement with students.

iii) Parents / family members

Parents and family members can involve in teaching their children or little brothers and sisters in a process of learning from home before they go to school.

1.6 REPORT ORGANIZATION

This report contains of five chapters. Chapter 1 explain about the overview of the project including the Introduction, Problem Statements, Objective of the project, Scope and Thesis Organization.

Chapter 2 briefly explain about the literature review on existing systems of AR for education field in process of learning for science education.

Chapter 3 explains about the methodology used in this project. This project implement ADDIE methodology. The stages that used in this project are Analysis, Design, Develop, Implementation and Evaluation.

Chapter 4 explains about result and discussion based on development and testing of this project. In this chapter, all the results and output of the project were briefly discuss. These include the software development, application testing, collecting data and result of the project.

Chapter 5 conclude and summarize the final result on this project. The limitation and further works were discussed thoroughly in this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Chapter 2 covers the review of available application of augmented reality in the field of education. Three existing augmented reality application in science education mainly in science were explained in details by focusing in term of its Graphical User Interface (GUI), Mobile Operating System (OS), language provided, connection type, target audience of application, topic covered in the application, size of application, type of augmented reality used, main function of the application, the advantages and disadvantages of the augmented reality application. This comparison of this existing application recommend the strength and effectiveness of existing application, so that this project can produce a better version of application.

2.2 AUGMENTED REALITY

Augmented reality (AR) is an enhanced version of physical, real-world environment which elements are augmented by computer generated sensory input such as sound, video, graphics or GPS data (Schueffel, 2017). AR brings virtual information to any indirect view to allow user interact with the real world (Mehmet Kesim, 2012). AR is a type of technology that allows a virtual 2D or 3D computer-generated image to be superimposed onto a real world environment (Lee, 2012). Many application of AR has been applied in many fields such as education, tourism, entertainments, marketing, manufacturing and others (Palmarini, Ahmet, Roy, & Torabmostaedi, 2018).

AR is different from Virtual Reality (VR) as in VR users are unable to tell the difference between simulated world and the real world, whereas in AR real world object are enhance with the help of virtually (Bhorkar, 2017). AR is a field in which 3D virtual objects are integrated into a 3D real environment real time (Liarokapis & Freitas, 2010). AR is a system that creates enriched real environment by merging to this predominantly real world objects as geometric models, images, sounds and text improving user perception(Matthias M.Wolka, 1995). AR seems something like magic because it creates traversable that establish the illusion that virtual and physical words are joined together and that user can physically cross from one to another (Thalman, Nadia Magnenat, 2012). Figure 2.1 shows the example of Augmented Reality application that available in the market.



Figure 2.1 Example of Augmented Reality Application

2.3 TYPE OF AUGMENTED REALITY

There are two type of AR which are Marker Based and Markerless. Marker – based AR (also called Image Recognition) uses a camera and some type of visual marker to produce result only when the marker is sense by a reader (Prahbu, 2017). It was a firstly introduced by Rekimoto (Rekimoto, 2014). Marker based applications use a camera on the device to distinguish a marker from any other real world object. It is usually a physical object or a piece of paper on which an icon has been printed. When user point the device, and AR experience appears over it. Figure 2.2 is an example of marker based AR application. The marker helps the camera determine where to position the object (Davis, 2017). Different type of AR markers are images that can be detected by a camera and used with software as a location for virtual assets placed in the scene. Most are black and white, though colour can be used as long as the contrast between them can be properly recognized by a camera (Katiyar, Kalra, & Garg, 2015).

Markerless (also called location-based, position-based or GPS) uses as a GPS, digital compass, velocity meter, or accelerometer which is embedded in the device to provide data based on your location (Prabhu, 2017). It uses something called SLAM (Simultaneous Location And Mapping) that allows user to place AR experience pretty much wherever they want, as long as it is fairly flat surface (Davis, 2017). Markerless tracking only uses what sensor can observe in the environment to calculate the position and orientation of the camera (Ziegler, 2012). Figure 2.3 shows the example of markerless based AR application. A strong force behind marker less AR technology is a wide availability of smartphone and location detection features they provide. It is most commonly used for mapping directions, finding nearby business, and other location – centric mobile locations.



Figure 2.2 Marker based AR Application



Figure 2.3 Markerless AR Application

2.4 REVIEW OF EXISTING SYSTEMS

This section explained about the review of three existing application of Augmented Reality in science education field. There are iScienceAR, AR3D Science and Libraries of life.

2.4.1 Application 1 – iScienceAR

iScienceAR is a new way to watch science come alive as never before. It is an application for mobile that available in the Google Play Store and App Store. User can install the application for free for both android and iOS. Figure 2.4 is the interface iScienceAR that available in Play Store. This application was developed by Red Frog Digital Limited.

To use this application, user need to get iScience book and download the app to explore and experiment with materials, atoms, gravity and chemical in the books. User need to tap on “Try the App” button and save the marker to trigger the AR or buy the iScience book directly from the “Get the Book” button. Then user need to point their device’s camera at the page, then user can see the world of Science comes to life. User can hear the sound effect by turning the volume up. Figure 2.5 is an example of 3D animation that produce by this application.



Figure 2.4 Interface iScienceAR



Figure 2.5 Example of 3D animation

2.4.2 Application 2 – AR3D Science

This application is an educational application experience for students to gain understanding. This AR learning system shows educational value that makes learning environment more attractive, simulating and exciting for students. User can get this application for free in Google Play only. This application developed by Panther Studio. Figure 2.6 is the interface of this application that available in Play Store.

This Interactive Educational AR application is to design and construct an Augmented Technology App for educational purpose in learning the fundamental concepts of AR Biology, AR Chemistry and AR Physics for Science in the schools. User need to download a marker to use this application. User can view Object life like 3D object in 3D view section of application. User also can touch, pinch in, pinch out and rotate the model. Figure 2.7 is example of 3D animation that produce by this application.



Figure 2.6 Interface AR3D science



Figure 2.7 Example of 3D Animation

2.4.3 Application 3 – Libraries of life

Libraries of life is learning tools that give an engagement with biodiversity specimens and their data through a set of augmented reality. It consists of fifteen cards that have different features and each cards launches a 3D model in the mobile devices that brings life for the user. User can download in their devices free for Android and iOS version. Figure 2.8 is interface of Libraries of life application in Play store. This application developed by ExplorMor Labs LLC.

User can obtain a full set of cards to engage with the app and download a free PDF to use for educational purpose. User can view specimen and can click button view to see the content. Figure 2.9 is example of 3D animation that produce by this application.



Figure 2.8 Interfaces of Libraries of Life



Figure 2.9 Example of 3D Animation

2.5 SUMMARY OF COMPARISONS OF THREE EXISTING SYSTEM

Based on the review done in Section 2.4, Table 2.1 shows a summary of the comparison of three existing system. There are 11 elements that used for comparison such as Graphical User Interface (GUI), Mobile Operating System (OS), language provided, connection type, target audience of application, topic covered in the application, size of application, type of augmented reality used, main function of the application, the advantages and disadvantages of the application.

Table 2.1 Comparisons of existing systems

Application Name	iScience AR	AR3D Science	Libraries of Life
Graphical User Interface	The interface is attractive.	The interface is beautiful with attractive background colour and well organize.	The interface is not well organize.
Mobile OS	iOS , Android	Android	iOS, Android
Connection Type	Offline	Offline	Offline
Language	English	English	English
Size	64.10 MB	78.87 MB	82.58 MB
Audience	Children, Students	Children, Students	Students
Topic Covered	Atoms, gravity, materials and chemical reaction.	Biology, Physic, Chemistry.	Specimen
Type of AR	Marker based	Marker based	Marker based
Main Function	<ol style="list-style-type: none"> 1. Provide button to start the application. 2. Provide Home button to navigate to home page. 3. Provide icon “camera “for user capture to capture the 3D image. 	<ol style="list-style-type: none"> 1. Provide button “AR view “and “3D view “at the home page for user select. 2. Provided button “Biology”, “Chemistry” and “Physics” for user select the topic they want to view. 3. Provide an information about 3D model represent. 	<ol style="list-style-type: none"> 1. Provide button “download cards” for user get the marker to view 3D model. 2. Provide the category of specimen button for user select category they want to view.

			3. Provide button “ exit “ to navigate to home page
Advantages	<ol style="list-style-type: none"> 1. Interactive 3D model animation pop up from the screen. 2. Provide the sound of the 3D model. 3. Provide screenshot button to save a picture. 	<ol style="list-style-type: none"> 1. 3D models of alphabets with 3D illustrations. 2. Categorized the 3D model view by topics. 3. User can touch, pinch In - pinch out and rotate the model. 	<ol style="list-style-type: none"> 1. 3D models look like living. 2. Provide info about the specimen model. 3. Provide the sound of the specimen represent and background sound.
Drawbacks	<ol style="list-style-type: none"> 1. User need to buy the book to use the application. 2. Do not provided the info about the 3D model. 3. The image on marker are not well organized 	<ol style="list-style-type: none"> 1. Not provided info about the model in AR view. 2. Not provided the animation for 3D model. 3. Not provided the home button for user navigate to the home page. 	<ol style="list-style-type: none"> 1. Some model take a longer time to display. 2. The button provided is small 3. The 3D model are not moving.

2.6 SUMMARY ON REVIEW EXISTING SYSTEM

From comparison of three applications which are iScience AR, AR3D Science and Libraries of life, there are advantages and disadvantages in every application.

In term of GUI, are iScience AR and AR3D Science application have a good interfaces compared to Libraries of Life application. The GUI look very attractive with background colours. For Libraries of Life application, the GUI is very simple and not well organize. All of three applications do not required internet to launch it. User can download the applications through Google Play Store and App Store except AR3D Science applications available for Android version only.

All the applications are covered topic in science education and the target audience are for students. Type of AR of this three application is marker-based. The main function for iScience AR is to see the interactive 3D model animation of Science world that pop up from the books/marker. The application have a good user navigation. It provide the home button for user return to home page. User also can capture the 3D model by click on the screenshot button. User can hear the sound produce by the 3D model.

AR3D Science application provide the two button which are button AR view and button 3D view at the home page for user select. This application also provided button according the topic for user easily select the topic they want to view. User can hear human voice pronunciation of model represented on the marker. User also can pinch in and out and rotate the model.

Libraries for Life also good in user control by providing the category of specimen button. It also provide the exit button for user return to home page. It also provide the info about the specimen model. User can hear the sound that produce by some of model.

This three application have their own weakness. For iScience AR, user need to buy a book to track the marker. The graphics on the marker is looking messy and not well organized. In this application, it does not have info about the 3D model represent. For AR3D Science application. The info about the model only provided in 3D view only and do not provided in AR view. This application not provided the animation for 3D model. The model only static without any movement. Other weakness in this application is do not provided the home button for user return to home page. In Libraries of Life application, the button provided are too small, Some of the model are take a longer time to load and the model do not have animation.

2.7 PROPOSED APPLICATION

In this project, the proposed application is Augmented Reality Science application that available for Android version. The target of this application is primary school student in age 10-12 years old. The topic covered is the water life cycle process, photosynthesis process and life cycle of butterfly. All the topics were based on the syllabus of science subject for primary school students. This application is marker based augmented reality and will use the poster as the target marker for student easy to visualise the process presented. This application can use without internet connection. After user scan the marker using the device, user can view the 3D animation that explain the process present.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Chapter 3 will discuss about the developing process in this project. It will review about methodology chosen to develop this project. Developing project need a good technique to make sure it can be done successfully. Methodology is known as general analysis procedure that outlines the action in which research is to be undertaken between other things, identify the technique to be used. These technique described in methodology, define the means or modes of data collection, ways to calculate the specific outcome (Howell, 2013).

There are various type of methodology such as in System Development Life Cycle (SDLC) also known as application development cycle that consist of six phase. These phases include planning, analysis, and design, implementation, testing, integration and maintenance. The most important SDLC model are Waterfall, Agile, ADDIE, V-shaped and Spiral models. A good selection in SDLC model can ensure the project is more accurate and appropriate project development. Each of SDLC model have their own advantages and disadvantages in development process.

3.2 TYPES OF SDLC

Software Development Life Cycle is known as one press to build a good software. The type of SDLC model is Waterfall model, Agile model, ADDIE model, V-shaped model and Spiral model.

3.2.1 Waterfall model

Waterfall model is a traditional methodology that is a linear sequential flow. The phases in Waterfall model consist Requirement, Design, Implementation, Verification and Maintenance. Figure 3.1 is the example of waterfall model. In this model, any phase in development process begins only if the previous phase is done. There is no turning back to the previous phase to change the requirement. The progress flow is steadily downwards (like waterfall). Table 3.1 shows the phases that consist in waterfall model.

Table 3.1 Phase of Waterfall Model

Phase	Description
Requirement	All requirement gathered and documented in a requirement specification document.
Design	All system design is specified like hardware and system requirements to defining the overall system architecture.
Implementation	All design phase are developed in small programs known as units. Each unit are developed and tested which are integrated in next phase.
Verification	All unit or component are tested and make sure developed component are function.
Maintenance	All issues that that occurs in production or reported by end user are fix. The version of better are release according to user requirements.

3.2.1.1 Advantages and Disadvantages of Waterfall model

The advantages of waterfall model is very easy to use and understand. It allows for departmentalization and control. The schedule each stages of development can be set with deadlines. The requirements are stability and good for management control. This model are works well for smaller projects and easy to arrange the task.

The disadvantages of waterfall model are it does not allow reflection and revision of each phase. After one phase is done, it very difficult to go back and modified something was not well- documented in previous phase. It is high amount risk and uncertainty of model development and it is not suitable for complex and object-oriented projects.

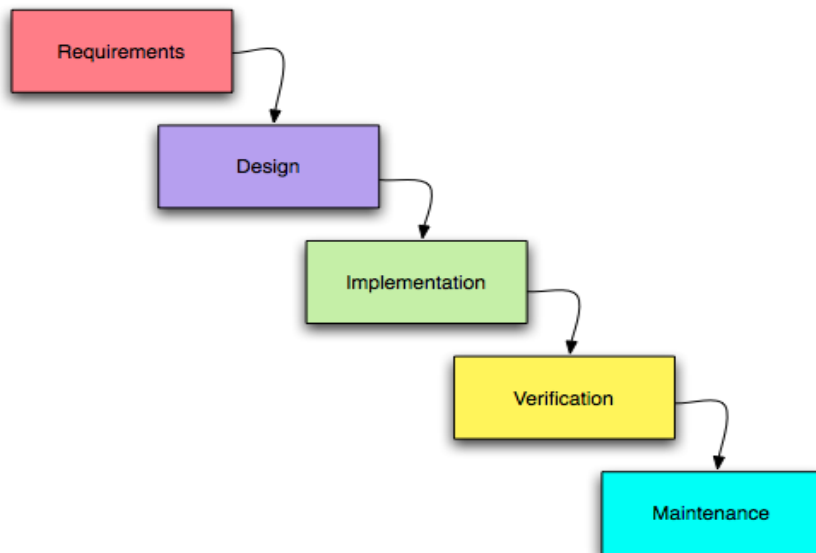


Figure 3.1 Waterfall model

3.2.2 Iterative model

Iterative model is a specific implementation process of SDLC. It is focus on initial, simplified implementation which will give more complex and feature set until final system is successfully complete. This model does not attempt to begin with full specification requirement. Development is start by specify and implementing only a part of the software to identify further requirements. This procedure is repeat to produce a new version of software in each cycle model. Figure 3.2 shows the phase in Iterative model. There are Planning, Analysis and Design phase, Implementation phase, Testing phase and Evaluation phase. The description of each phase are discuss in Table 3.2.

Table 3.2 Phase in iterative model

Phase	Description
Planning	A proper planning are done to identify the specific document needed, establish software or hardware requirements and prepare for next phase of the cycle.
Analysis and Design	Analysis the appropriate business logic, database, other and identify other requirement in this phase. Technical requirement are established and utilized to meet the need in this phase.
Implementation	Executed the actual implementation and coding process. All the planning, specification of requirement and design documents are coded and implemented.
Testing	Apply the testing of the project to identify and locate the potential error and bugs or issues that may have been in this software.
Evaluation	Meet with client to examine status of the project and validate based on suggested document.

3.2.2.1 Advantages and Disadvantages of Iterative model

The advantages using iterative model in software development process is less in time consuming. The documenting process does not much time because it more focus on designing process. It is easy to manage potential risk because risk are identify and handled during its iteration. This model is implement during the earlier phase which allows developer and tester can find functional or design that related weakness as early as possible.

There are few drawbacks in this model such as, each phase is rigid with no overlaps. The Design issues may arise due to not all requirement are gathered in the earlier phase of this model. High skill resources are needed for analyse the potential risk. This model is not suitable to implement in smaller project.

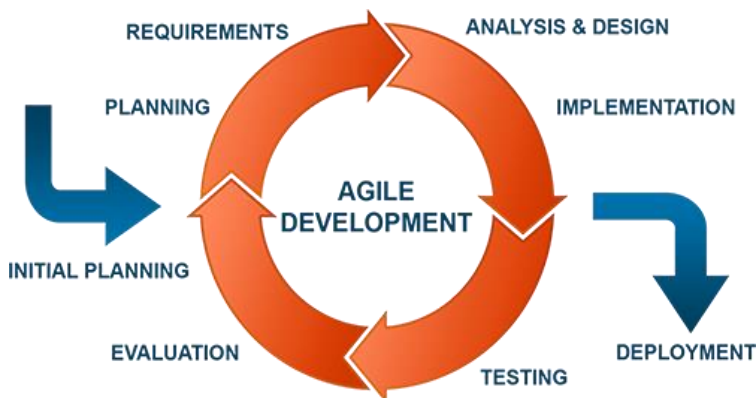


Figure 3.2 Iterative model

3.2.3 ADDIE model

ADDIE model is a way that used by designer and developer to create instructional course material. This model is flexible to use as the standard method by many designer. It can be used in both individualized and traditional instruction. ADDIE model consists of five phase which are Analysis, Design, Development, Implementation and Evaluation. Figure 3.3 shows the phase on ADDIE model. A description about each phase are explain in Table 3.3.

Table 3.3 Phase in ADDIE model

Phase	Description
Analysis	Identify the learning problem, goals, objectives, target audience, existing knowledge and other relevant characteristics.
Design	Specify the learning objectives and designed detail storyboards and prototypes. The storyboards and prototype are designed to make sure easily communicate with other stakeholders.
Development	Each of element of the application is developed based on design phase.
Implementation	Developing procedure for training the client.
Evaluation	This phase consists of formative and summative evaluation. Formative evaluation is present in each phase. Summative evaluation is testing a designed for criteria – related and providing a feedback from client. The feedback is gather to identify the require improvement in the application.

3.2.3. Advantages and Disadvantages of ADDIE model

The advantages of using ADDIE because it has been so successful that associated with good quality design, clear learning objective, well-structured content. ADDIE can be used in a large range instructional materials because it is generic instructional design model. This model is one of neat arrangement that can ensures there is no task are miss out at the later phase. It can save cost and effort of manpower for maintenance process if there are any problem occur.

The disadvantages of this model is the process is too systematic. The process can become overwhelming as more as information is added and when changing are made during the design phase. This model only focus on content design and development process only.

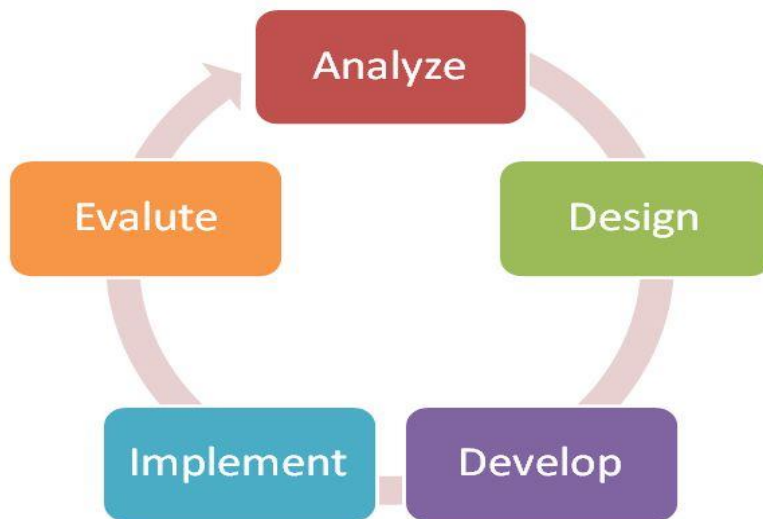


Figure 3.3 ADDIE model

3.2.4 V-shaped model

V-shaped model also known as Verification and Validation model. It is extension of the waterfall model. V shaped model is a sequential path of execution processes like waterfall model. The flow of each phase is in V shape which is moving down in a linear way and after implementation phase it bent upwards Figure 3.4 shows the phase of V- shaped model that consists Planning, Requirements, Architecture, Detailed Design, Implementation, Unit Test, Integration Testing, System and Acceptance Testing and Maintenance. In Table 3.4 will discuss the task of each phase.

Table 3.4 Phase in V- shaped model

Verification Phase	
Phase	Description
Requirements analysis	Analyse the system requirement to determine the features and needs of client. The developer need meets client regularly to fully understand client's goal and wants.
System Design	Analyse and understand the proposed system from client by studying requirement document. Designing the complete system are done in this phase.
Architecture design	Understand and design architectural specifications.
Module design	Specify the detailed of internal design for all system modules, known as Low Level Design (LDD). Design system are split into smaller unit or modules. Each of them is explained for programmer can start coding directly.
Coding	Designed the actual coding of the system. The type of programming language is decided based on the system and architectural requirements.
Validation Phases	

Unit testing	During module design phase, Unit Test Plans (UTPs) are developed. UTPs are executed to eliminate bugs at code level or unit level.
Integration testing	Integration testing is relate with the architectural design phase. Integration tests are performed to ensure the system functions achieve all requirements.
System testing	System testing is directly related with the design phase. This phase process is checking the entire system functionality and the communication of the system. All software and hardware compatibility issues can be discovered during system test execution.
User Acceptance testing	Acceptance testing is process of implementing all test created during the earlier phase. It involves testing the product in user environment. User Acceptance Test (UAT) is performed to get feedback from user. Acceptance tests uncover the compatibility issues with the other systems available in the user environment.

3.2.4.1 Advantages and Disadvantages of V-shaped model

The advantages of V- shaped model is it simple and easy to use. This development model can save a lot of time due to test designing are done before coding phase. It work efficiently for small project due to requirement are easy to understand.

The disadvantages of V-shaped model is it rigid and not flexible. There is no early prototype are produced since software is developed during implementation phase. If the application in testing phase, it difficult to turn back to previous stage to make a change.

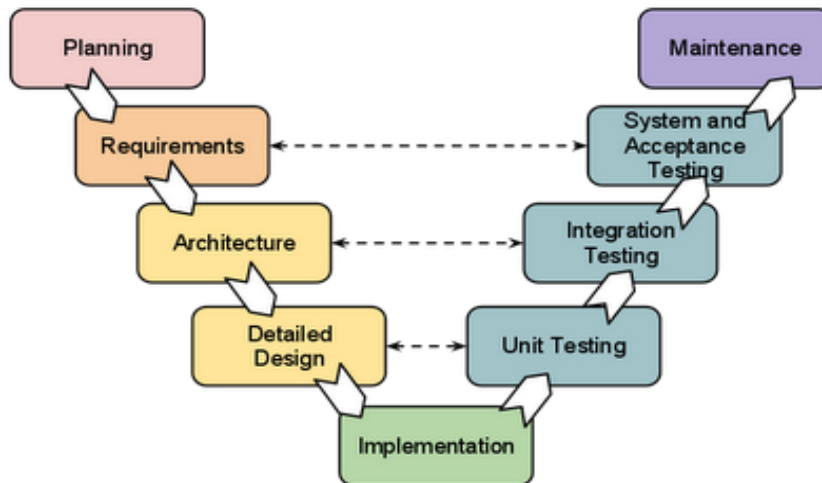


Figure 3.4 V- shaped model

3.2.5 Spiral model

Spiral model known as SDLC model that combines sequential and prototype model. This model is more emphasis placed on risk analysis. Figure 3.5 is the example of Spiral model. There are 4 phase in spiral model which are Planning, Risk Analysis, Engineering and Evaluation. Each phase begins with a design goal and end with client reviewing the progress. Table 3.5 shows the description of each phase in spiral model.

Table 3.5 Phase in Spiral model

Phase	Description
Planning	Requirement are gathered such as Business Requirement Specifications and System Requirement Specifications.
Risk analysis	Identify potential risk and alternate solution.
Engineering	Development and testing process are done in this phase
Evaluation	Clients can evaluate the output of the project before continue to next spiral.

3.2.5.1 Advantages and Disadvantages of Spiral model

Spiral model have its own advantages. The cost estimation is low due to prototype are built in small fragments. Any changes or additional functionality can be done in later stage. The development no take so much time and features are added in systematic way.

The bad in using spiral model is it risk analysis requires high specific expertise. The successfully of the project are depends on risk analysis phase. For a small project, this model is not suitable to use because may cause process doesn't work well.

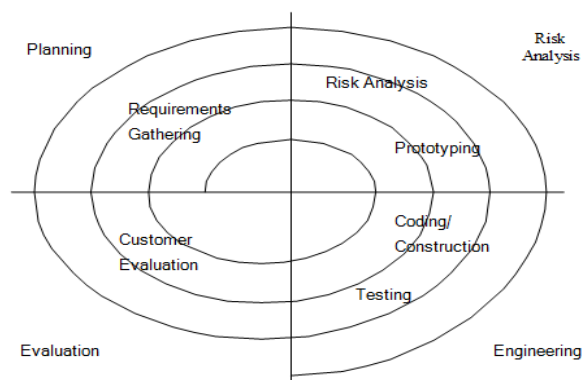


Figure 3.5 Spiral model

3.2.6 Comparison between SDLC model

Based on the review above, table 3.6 shows a summary of comparison of five different SDLC models. There are 8 elements used for the comparison such as simplicity of the model, cost, flexibility, risk factor, guarantee to success, flexible in change the requirement, the frequency meet the client and time required to finished the application.

Table 3.6 Comparison of five different SDLC models

FEATURE	WATERFALL	ITERATIVE	ADDIE	V-SHAPED	SPIRAL
Simplicity	Simple	Simple	Simple	Simple	Complex
Cost	Low	Low	High	Expensive	Expensive
Flexibility	No	No	Yes	Yes	Yes
Risk factor	High	High	High	Less	No
Guarantee Success	Low	Low	High	Medium	High
Flexibility to change	Difficult	Easy	Easy	Difficult	Easy
Client Interaction	One time	One Time	Frequent	Frequent	Some
Time Required	Few	Few	More	More	More

3.3 CHOSEN METHODOLOGY (ADDIE MODEL)

Based on analysis above, the selected methodology is ADDIE due to many aspect, which are this SDLC support flexible change requirement, flexible to use, high guarantee of success and frequent meet the client to satisfied client needs. Each phase is explain in this section. As mentioned above, ADDIE methodology consist of five phases which are Analysis, Design, Develop, Implement and Evaluate.

3.3.1 Analysis

Analysis phase is focus on defining the scope of project until the end of development process. The scope of this project include the location, client, user, system and development scopes. This project is more focus on students in age 10 – 12 years old that study in Gambang area. This project covered the topic of photosynthesis, water cycle and life cycle of butterfly only and will review topic in science subject only.

Learning problem are identified in this phase to identify what users faced and how to overcome the problem when the project are develop. The learning problem are based on the issue in learning environment in science education. The proposed solution that will develop should be able to solve the problem that user faces. After learning problem are defined, objectives can be identify. Objective are important in development of project to make sure the goal can be achieve.

The timeline for this project is estimated to make sure the project can be completed in around 9 months. Refer to Figure 3.12 timelines of project development.

3.3.2 Design

Design phase is to create the structure of this project. The information in the Analysis phase are used to develop this project that met of the client need. The design of the system are based on the requirement collect from the user of this system. System designing must be built based on the criteria and make sure it user friendly and ease to use. This system will allow user to learn science in the Augmented Reality environment. User will learn science in an interactive way by point the device at the printed poster, then a beautifully rendered 3D will pop up on the screen. User can see the animation of the topic represent. The Context diagram are shown in Figure 3.10.

3.3.3 Development

Develop phase is start after design phase is finished. The good design give advantage to the developer to proceed with this phase. A few software tools will be used to develop this application. Refer to Table 3.11. Adobe Photoshop are used to develop a marker of image, Unity 3D used to create AR environment, Vuforia SDK to plugin image target database and Autodesk Maya to create the 3D model. For process

of creating marker for the image are shown in Figure 3.7. The flow of creating 3D model are shown in Figure 3.8. The overall flow of this application are shown in Figure 3.9.

3.3.4 Implementation

Implementation phase is process of presenting the system that have been developed to the client. The system will be tested in term of concept and material. The system will be view to client for testing. The teacher of primary school, Cik Nor Ashlia binti Saidi will be first user to test this system. This is to identify any error or any update that should be carry out to the system. Respond from the first user will be recorded.

3.3.5 Evaluate

Evaluation phase are divided into two part which are Formative and Summative evaluations. All stage of phases in ADDIE model present formative evaluation. Evaluation is presented in every decision that has been made up. Summative evaluation is made for the user after the application is successfully completed. Any improvement or change in the application are based on the feedback and measures of effectiveness of this application. User Acceptance Test (UAT) are used to observe on user reaction. Refer to Appendix A. If the project did not achieve the objective, application need to revise back and reanalysis the error occur and implement in back.

3.4 WORK-BREAK DOWN STRUCTURE

Figure 3.6 show the work-break down structure for this project.

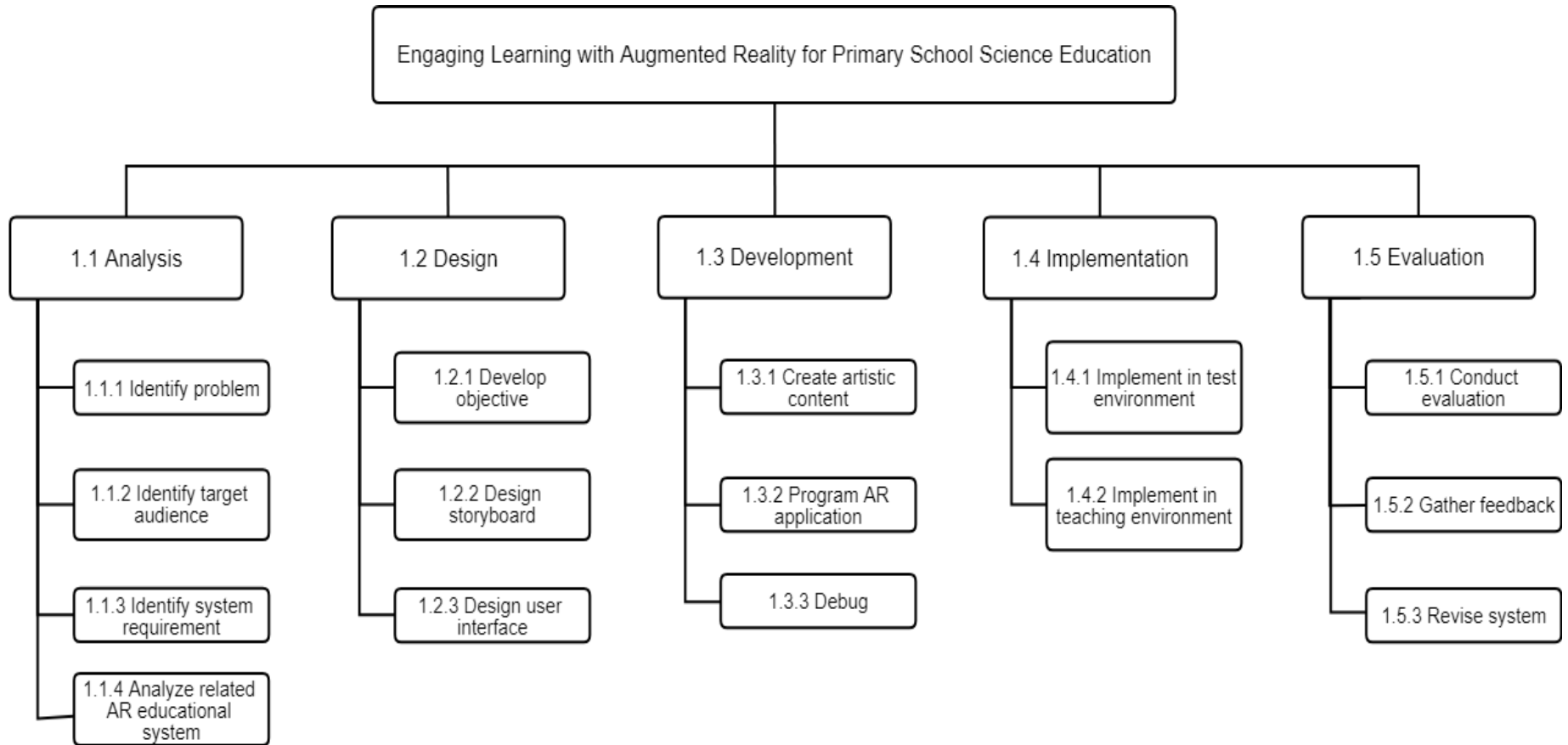


Figure 3.6 Work - break down structure

3.5 FLOWCHART

Flowchart is use to represent a workflow of the process. Figure 3.8 shows the flowchart to build the 3D model. The first process is creating the model using software Autodesk Maya 2016, then insert the texture and apply animation the model. After the model is develop, the object model is export into obj. format. Figure 3.7 shows the flowchart in creating AR environment. Obj. format of the object model need to import in Unity, the process of creating a marker can be done. After print out the marker, the marker can test using any mobile device.

Figure 3.9 shows flowchart of AR science application. The user need to open the application in the mobile device and click the AR Camera button at the home page. User can start to scan marker / poster, then the 3D animation will pop up on the screen. If user click on the quit button, the application will closed.

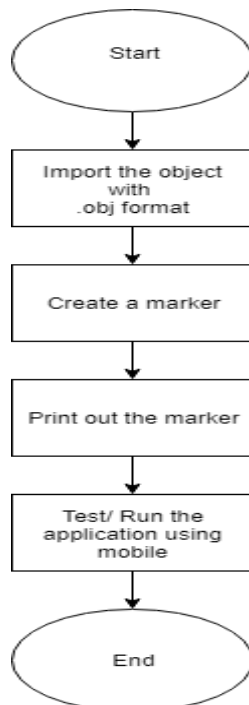


Figure 3.7 Flowchart creating AR environment

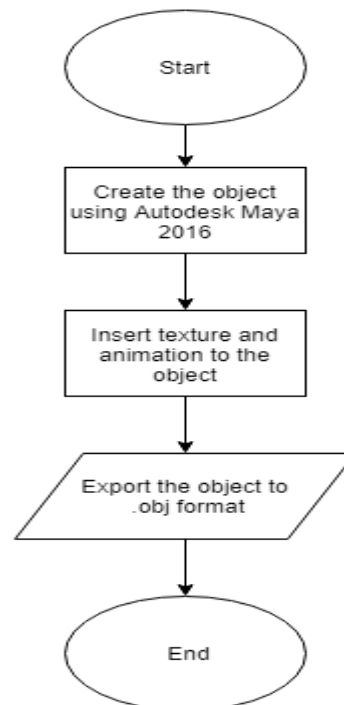


Figure 3.8 Flowchart build 3D model

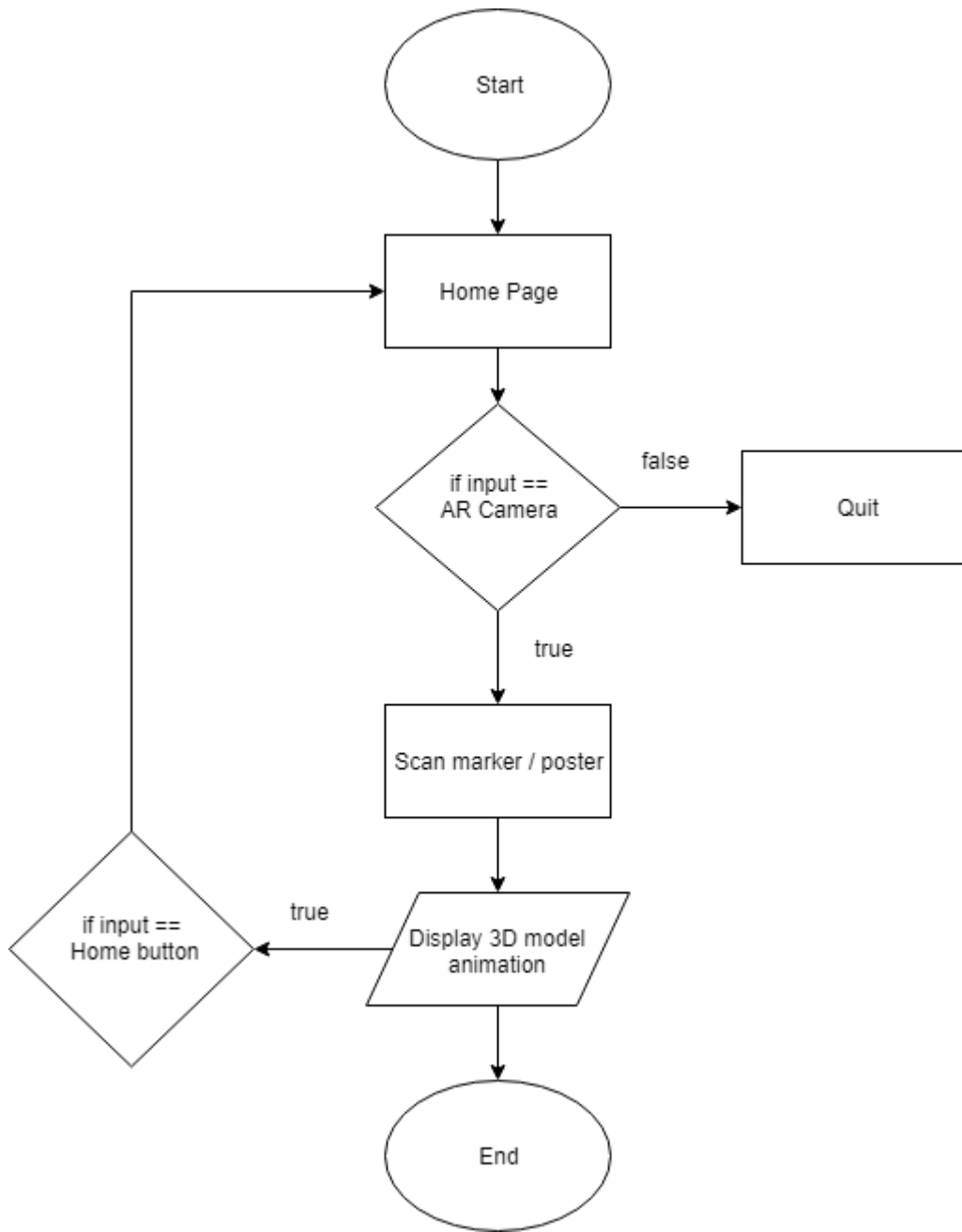


Figure 3.9 Flowchart of AR science application

3.6 CONTEXT DIAGRAM

Figure 3.10 shows a context diagram for AR science application. It shows the process (shape) of the system to model. It also shows the participants who will interact with the system known as external entities. In this context diagram, Developer and Client are the entities who will interact with the system. Based on the diagram, developer create 3D model with marker and Client can access the system and view 3D model animation AR environment.

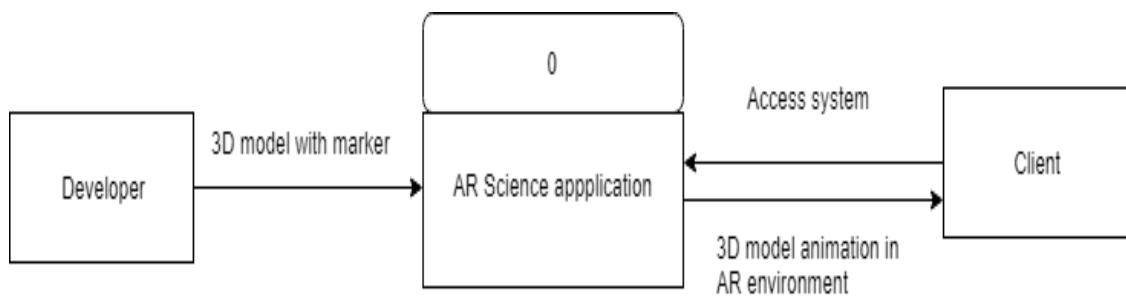


Figure 3.10 Context Diagram

3.7 USE CASE DIAGRAM

Figure 3.11 shows the use case diagram of this system. Use case can describe the relationship between the user and the system. After user load the application, user can scan the marker/ poster to view the 3D model animations. After scan the marker, 3D animation will pop up on the screen.

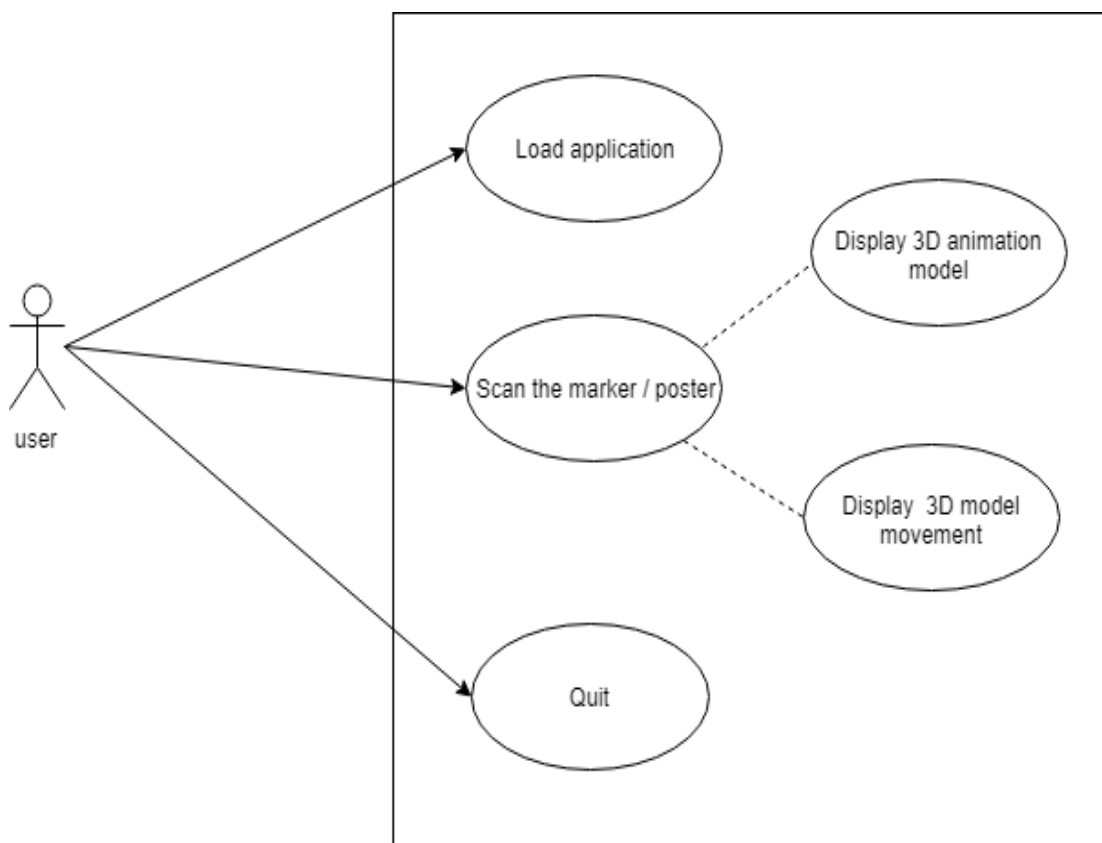


Figure 3.11 Use Case Diagram

3.8 STORYBOARD

Table 3.7 Home page interface

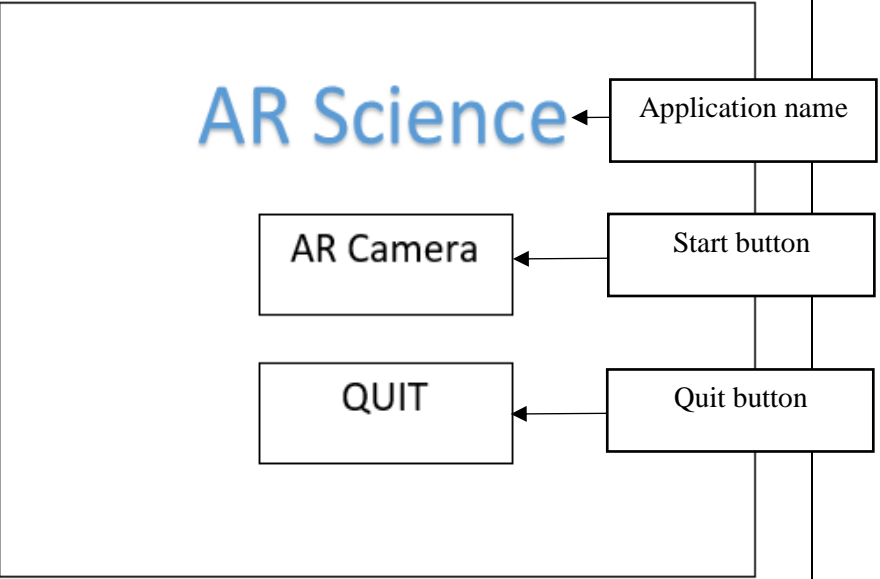
Screen title:	Home page
Layout :	01
Screen Layout:	
Screen Description	<p>This page show the home page of this application. There are two button which are AR Camera button and quit button. When user click at AR Camera button, it navigate to the screen user can scan the marker of the image. If user click quit button, it will close the application.</p>

Table 3.8 Water Cycle Process interface

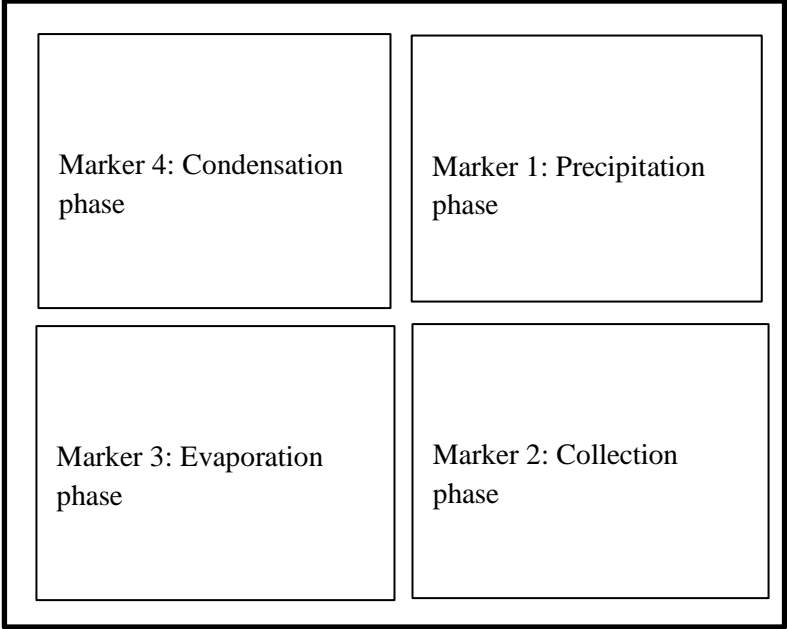
Screen title:	Poster Water Cycle
Layout :	02
Screen Layout:	
Screen Description	<p>This page show the markers in water cycle poster. Marker 1 represent precipitation phase process, Marker 2 represent Collection phase process, Marker 3 represent Evaporation phase process and Marker 4 represent Condensation phase process. When user point the device to target marker, the application will show the 3D animation of represent marker. User also can hear audio explanation about the process presented.</p>

Table 3.9 Photosynthesis Process interface

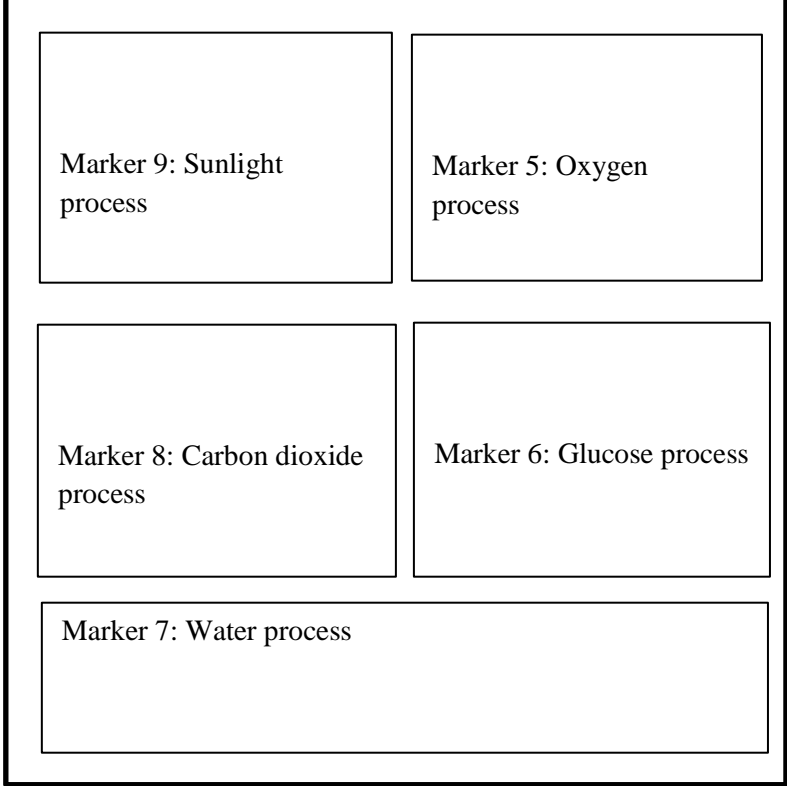
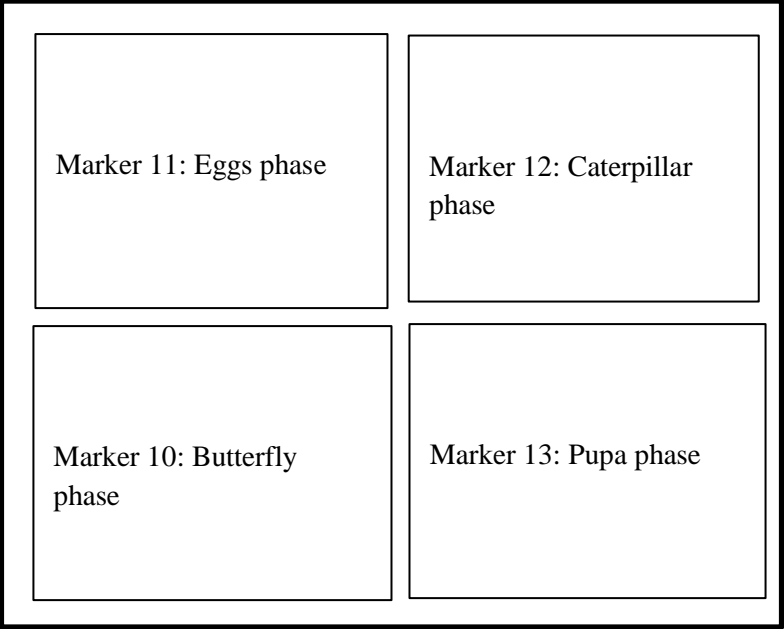
Screen title:	Poster Photosynthesis
Layout :	02
Screen Layout:	 <p>The diagram illustrates the layout of a Photosynthesis poster interface. It consists of five rectangular markers arranged in a grid. The top row contains two markers: Marker 9 (Sunlight process) on the left and Marker 5 (Oxygen process) on the right. The middle row contains two markers: Marker 8 (Carbon dioxide process) on the left and Marker 6 (Glucose process) on the right. Below these four markers is a single, wider marker labeled Marker 7 (Water process). The entire grid of markers is enclosed within a thick black border.</p>
Screen Description	<p>This page show the markers in Photosynthesis poster. Marker 5 represent Oxygen process, Marker 6 represent Glucose process, Marker 7 represent water process, Marker 8 represent Carbon dioxide process and Marker 9 represent Sunlight process. When user point the device to target marker, the application will show the 3D animation of represent marker. User also can hear audio explanation about the process presented.</p>

Table 3.10 Life Cycle of Butterfly interface

Screen title:	Poster Life Cycle of Butterfly
Layout :	02
Screen Layout:	
Screen Description	<p>This page show the markers in Life Cycle of Butterfly poster. Marker 10 represent Butterfly phase process, Marker 11 represent Eggs phase process, Marker 12 represent Caterpillar phase process and Marker 13 represent Pupa phase process. When user point the device to target marker, the application will show the 3D animation of represent marker. User also can hear audio explanation about the process presented.</p>

3.9 SOFTWARE AND HARDWARE REQUIREMENT

To develop the successful application, the high quality of software and hardware are needed. Hardware and software are main requirement for application to function properly. The specific software and hardware requirements that will be used to develop this application were discussed as below in Table 3.11 and 3.12.

3.9.1 Software Requirement

Table 3.11 shows the list of software component for this system that will be used and support to complete this application.

Table 3.11 List of software requirement

No	Software	Purpose
1	Vuforia SDK	To develop augmented reality application, animate 3D model, modelling, simulation and rendering the model.
2	Unity 3D	
3	Autodesk Maya	
4	Adobe Photoshop CS6	To edit images
5	Microsoft Word 2013	To documentation, table and diagram
6	Microsoft Project 2013	To create Gantt Chart

3.9.2 Hardware Requirement

Table 3.12 shows the list of hardware requirement that used to develop this system. The high technology is needed in produced a high quality system.

Table 3.12 List of hardware requirement

Hardware	Specification	Purpose
Laptop (Acer)	<ul style="list-style-type: none"> - Windows 10 - Intel Core i5-7200U - NVIDIA GeForce 940 MX with 4GB Dedicated VRAM - 64-bit OS 	For development and documentation of the system and build the interface.
Printer (EPSON L220 Series)	<ul style="list-style-type: none"> - Dimensions 482 x 300 x 145 mm (Width x Depth x Height) - 5,760 x 1,440 DPI 	For document printing and review.

	<ul style="list-style-type: none"> - 7 pages/min Monochrome, 3.5 pages/min Colour 	
Huawei MediaPad M3 Lite	<ul style="list-style-type: none"> - Dimensions 213.3 x 123.3 x 7.5 mm (8.40 x 4.85 x 0.30 in) - Octa-core 1.4 GHz Cortex-A53 - 8.0 Megapixel - Li-Po 4800 mAh battery 	To view the 3D model in android version.
Kingston USB Flash Drive	<ul style="list-style-type: none"> - 8GB 	Backup data

3.10 GANTT CHART

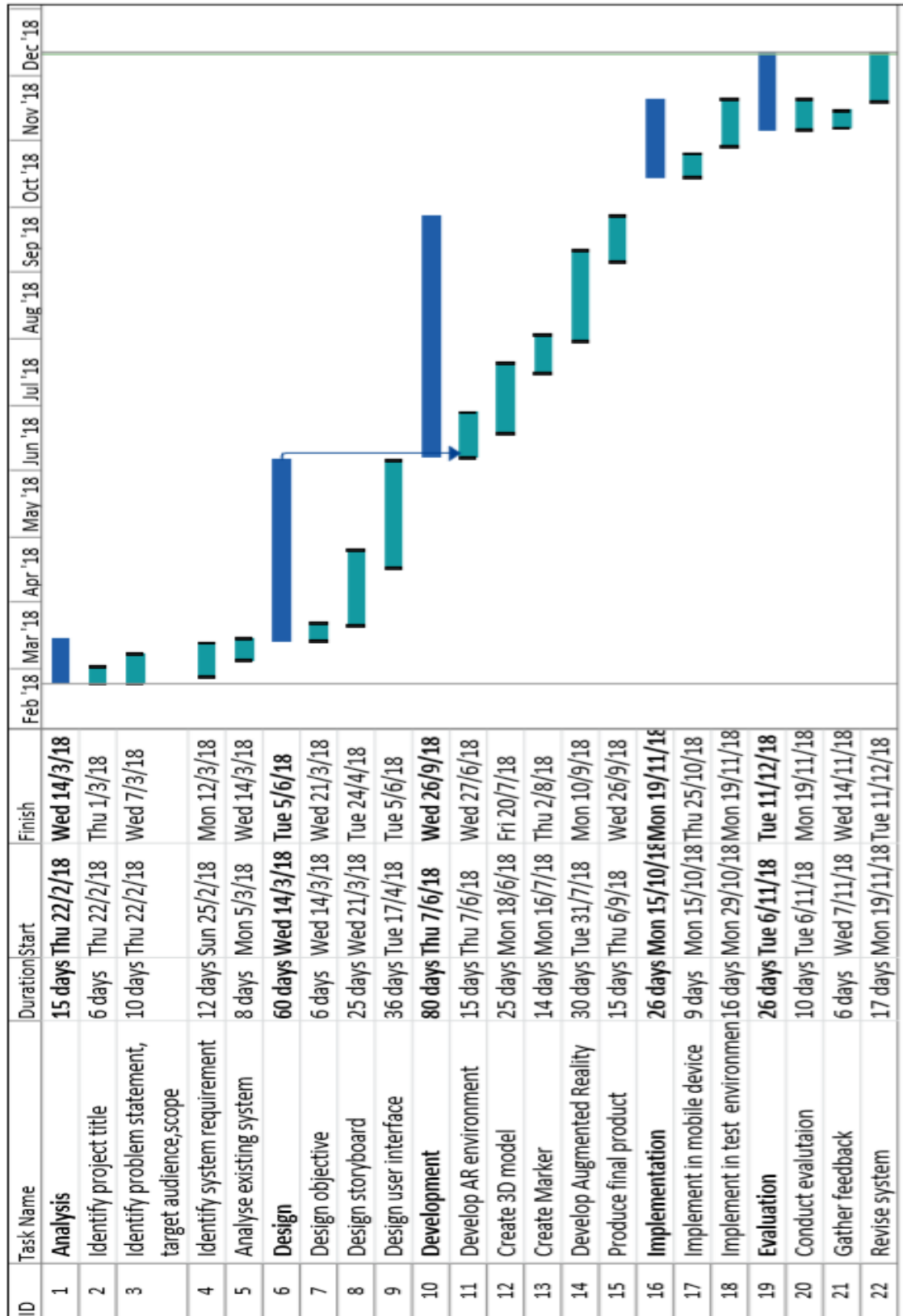


Figure 3.12 Gantt Chart

3.11 IMPLEMENTATION

This application will be implement to target user of this application that have been specific in earlier phase in ADDIE model (Analysis phase). This will implement to the students in age 10-12 years old whose studied in primary school in Gombang. It will involve 10 students from that school to test the application.

3.12 TESTING

User Acceptance Test (UAT) Form are used to determine either the application is fully test or not (Appendix A). Figure 3.13 shows evaluation form for student whose are test this application. Evaluation Form are used to observe on user feedback. Any improvement or change in the application are based on the feedback and measures of effectiveness of this application.

Evaluation for Students

Following the study, each student was asked to rate six short and simple questions. As the participants were young children, a smiley face-based was used as it is fun and easy to complete. For the survey, the experimenter read the question and the participant tick the appropriate column.































No	Questions	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	Do you like this AR Science application?					
2	Do you enjoy this AR Science application?					
3	Do you gain information when using this application?					
4	Do you think AR Science application help in understanding in subject science?					
5	Do you want to play this AR Science application again?					
6	Do you want to have this AR Science Application?					

Figure 3.13 Evaluation for students

CHAPTER 4

IMPLEMENTATION, RESULT AND DISCUSSION

4.1 INTRODUCTION

Chapter 4 will discuss about the development, implement and testing of Augmented Reality Science Application. There are important component that are used to develop this project such as target marker, interface, 3D model, and animation. This application is implement to the primary school students. The testing application was performed to identify the possible error and fixed it immediately.

4.2 IMPLEMENTATION PROCESS

The implementation process is to record all the steps in developing Augmented Reality Science Application. The application is using mobile as a device with AR camera function and included a poster which contains a collection of markers that allows user to scan by point the AR camera device to target marker. User can view the augmented reality contents such as 3D models, animation and audio on target marker.

4.2.1 Development of Markers

The marker is used in this application as image target. Markers are used for AR camera to find optical square markers and estimate their relative pose to camera to display virtual 3D model (Ćuković, Gattullo, Pankratz, & Devedžić, 2015). In this project, 13 different markers are designed using Adobe Photoshop CS6. The markers display different virtual information on 3 different types of poster which are Water Cycle poster (Figure 4.1), Photosynthesis poster (Figure 4.2) and Life Cycle of Butterfly poster (Figure 4.3).



Figure 4.1 Poster Water cycle process

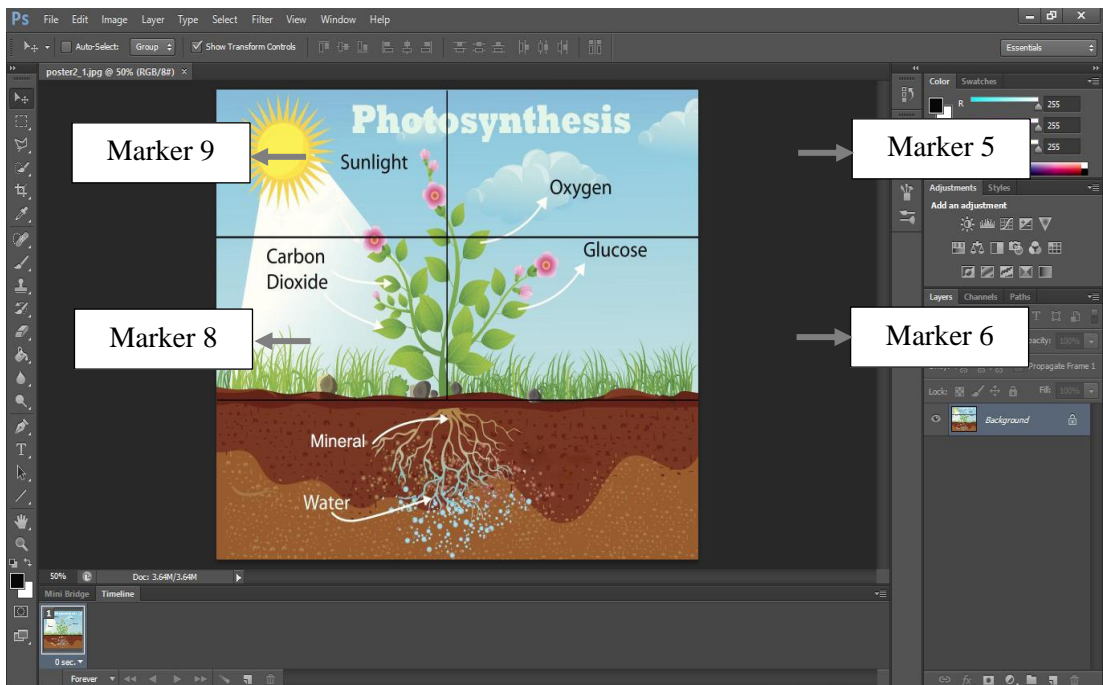


Figure 4.2 Poster Photosynthesis process

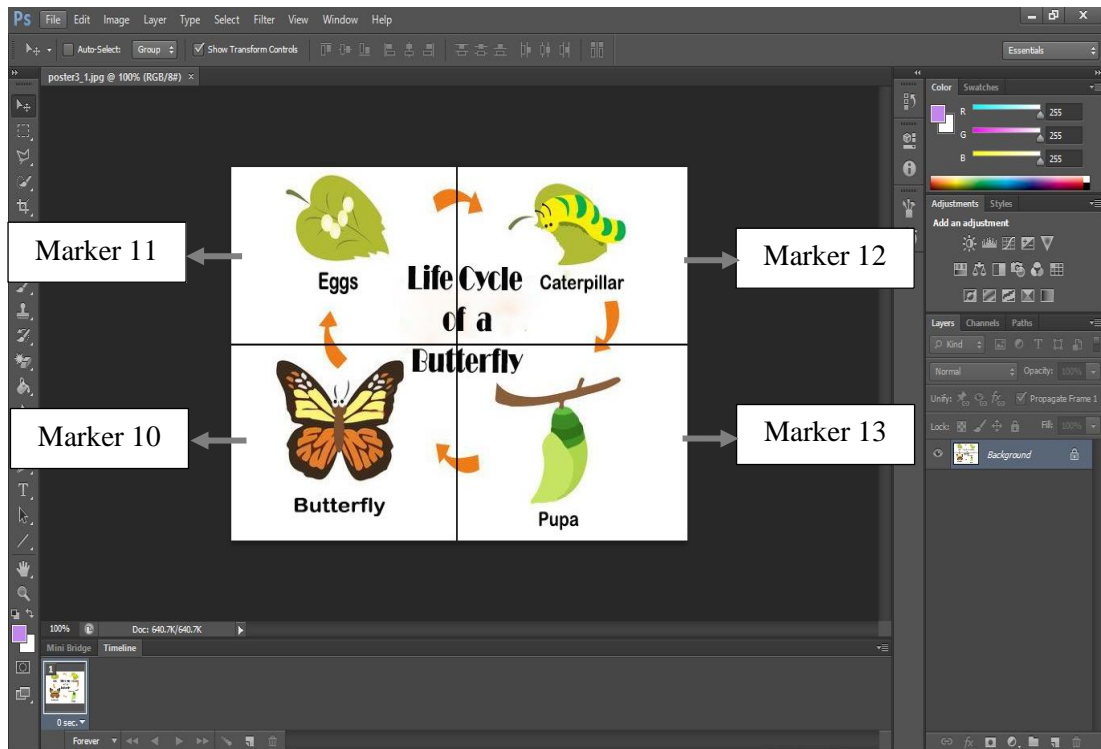


Figure 4.3 Life Cycle of Butterfly poster

After designing the markers, all the markers need to be uploaded and save in Vuforia Target Manager Database. To upload the markers, log in process is needed as shown in Figure 4.4. After create new database as shown in Figure 4.5 and Figure 4.6, the new image target need to create to upload the markers as shown in Figure 4.7. The database later will use in developing AR application. After uploading all markers in Vuforia, the database package will be downloaded in Unity Editor and import into Unity project as shown in Figure 4.8 and 4.9

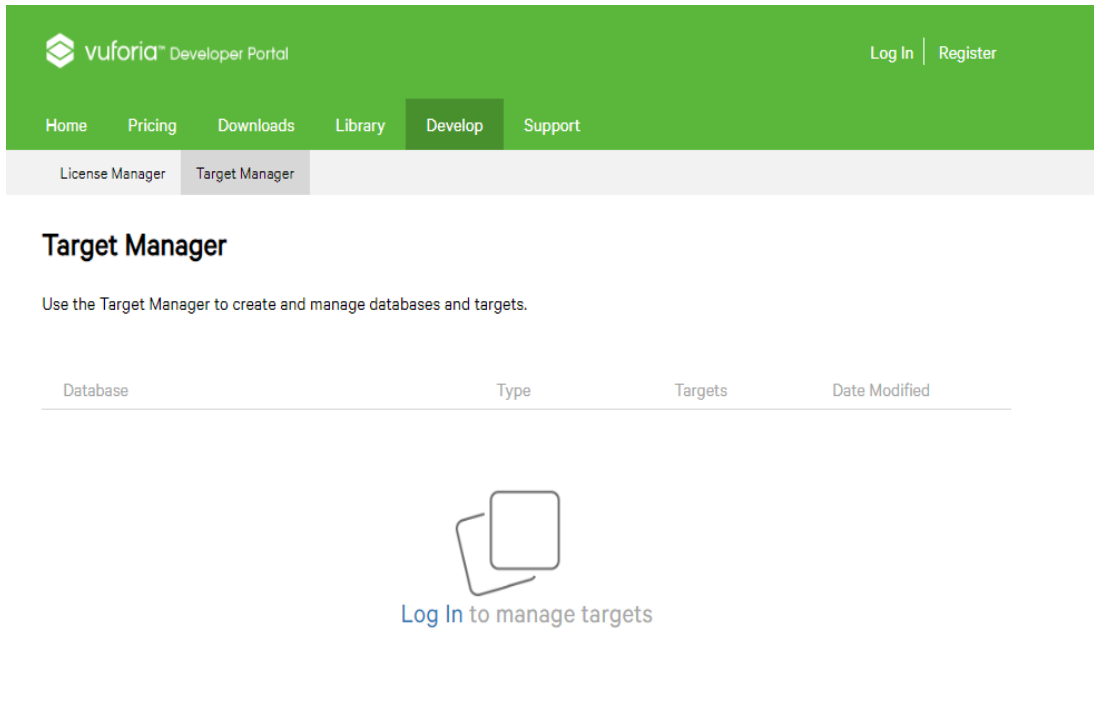


Figure 4.4 Open Vuforia Developer Portal

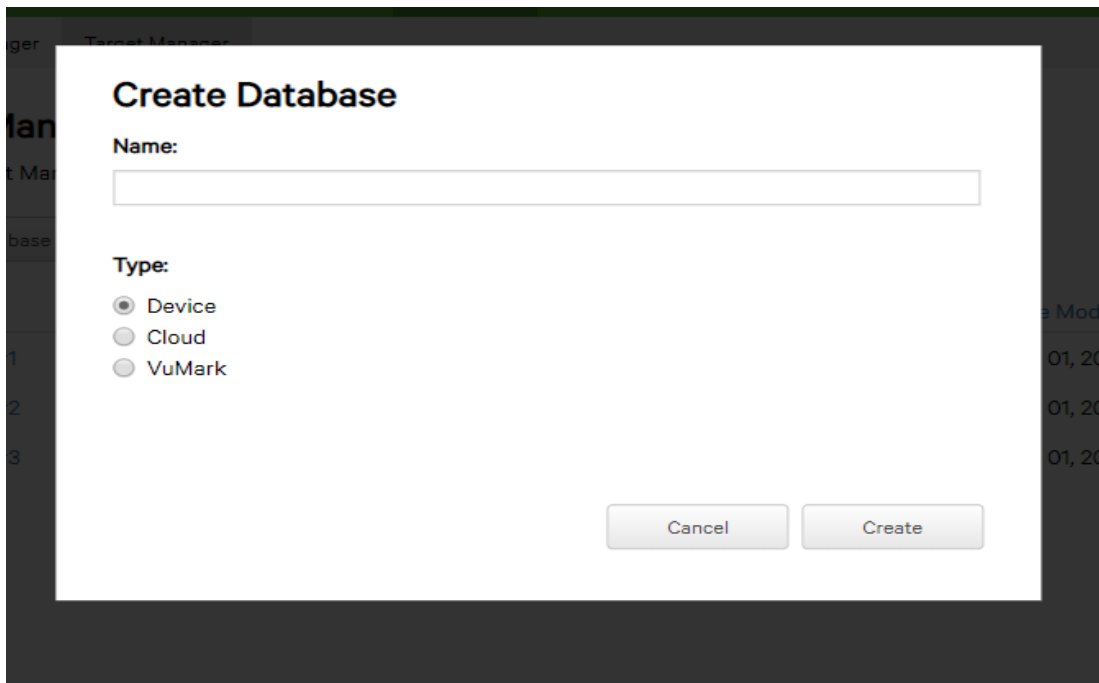


Figure 4.5 Create new database in Vuforia Developer Portal

Target Manager

Use the Target Manager to create and manage databases and targets.

Add Database

Database	Type	Targets	Date Modified
MarkerPoster1	Device	4	Dec 01, 2018 17:37
MarkerPoster2	Device	5	Dec 01, 2018 17:40
MarkerPoster3	Device	4	Dec 01, 2018 20:04

Figure 4.6 Add database in Vuforia Developer Portal

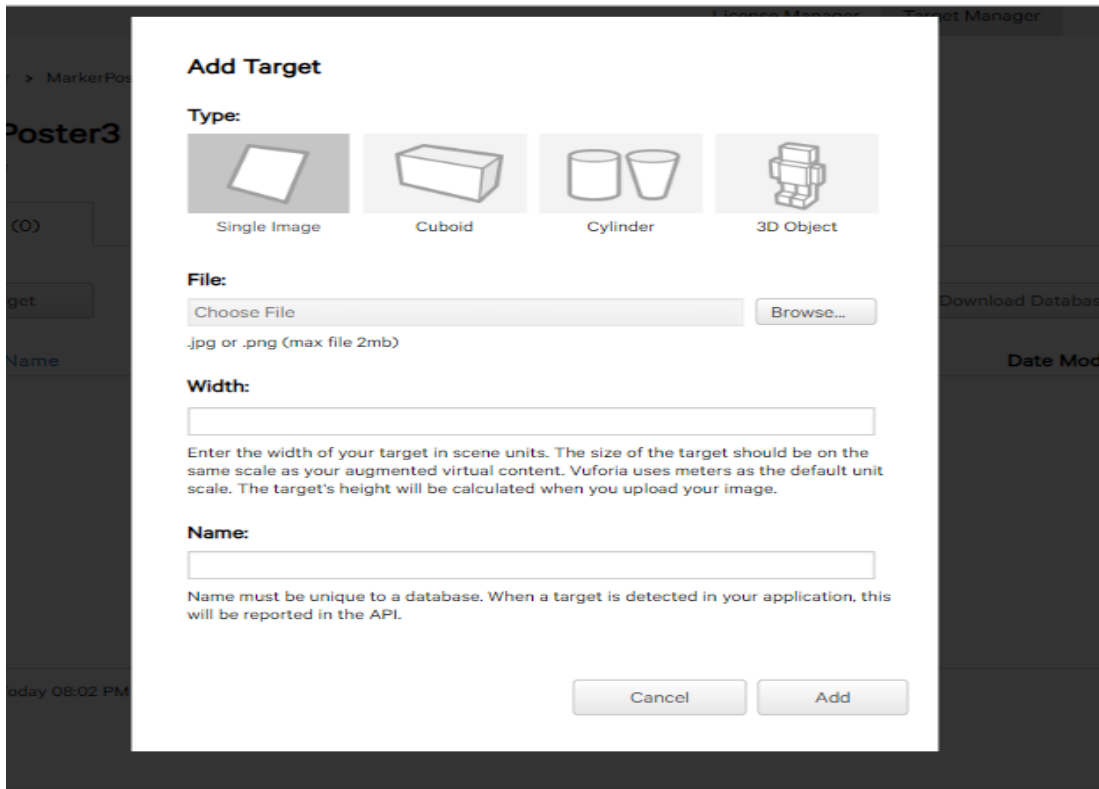


Figure 4.7 Add new image target

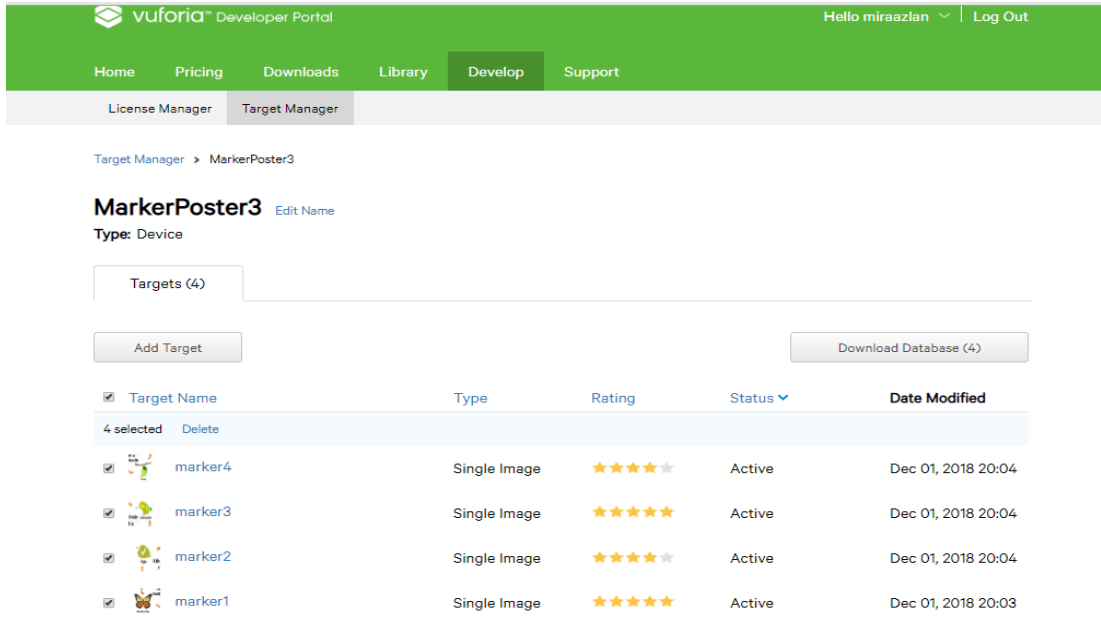


Figure 4.8 Select all markers to download

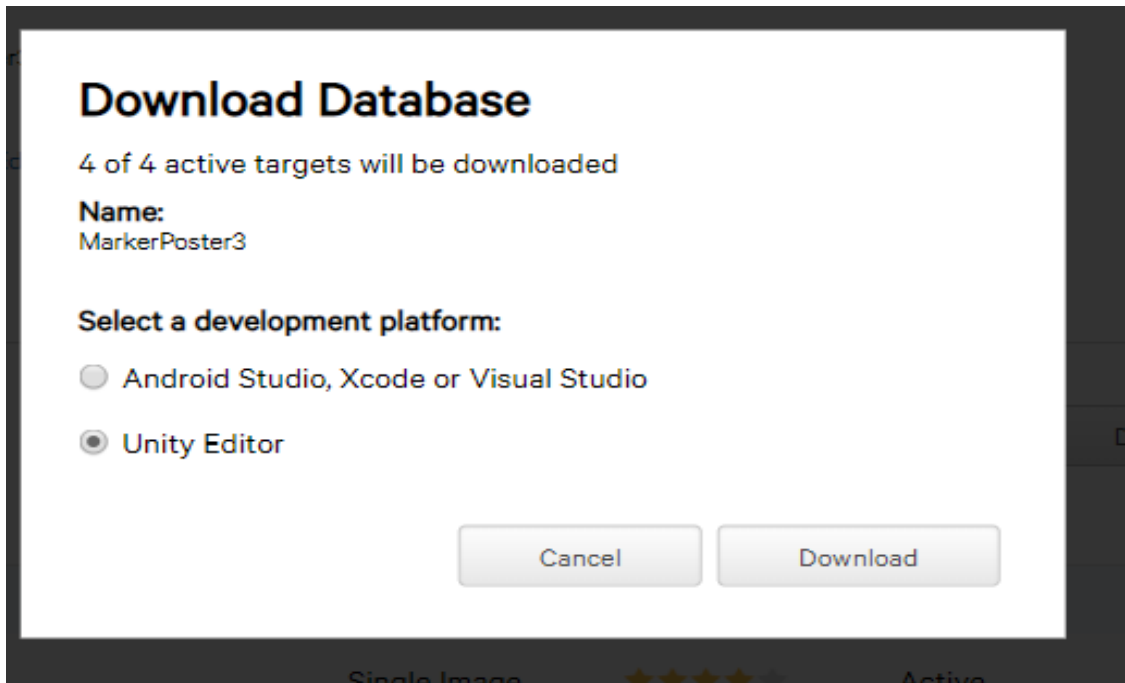


Figure 4.9 Download image target in Unity Editor

4.2.2 Development of 3D Model

Before start developing the application, 3D model are developed in Autodesk Maya 2016 as shown in Figure 4.10. All modelling, editing and texturing of the model are done using this software. After the model are done editing, all the models need to be exported into format FBX file which can successfully import to Unity software for the development of the application.

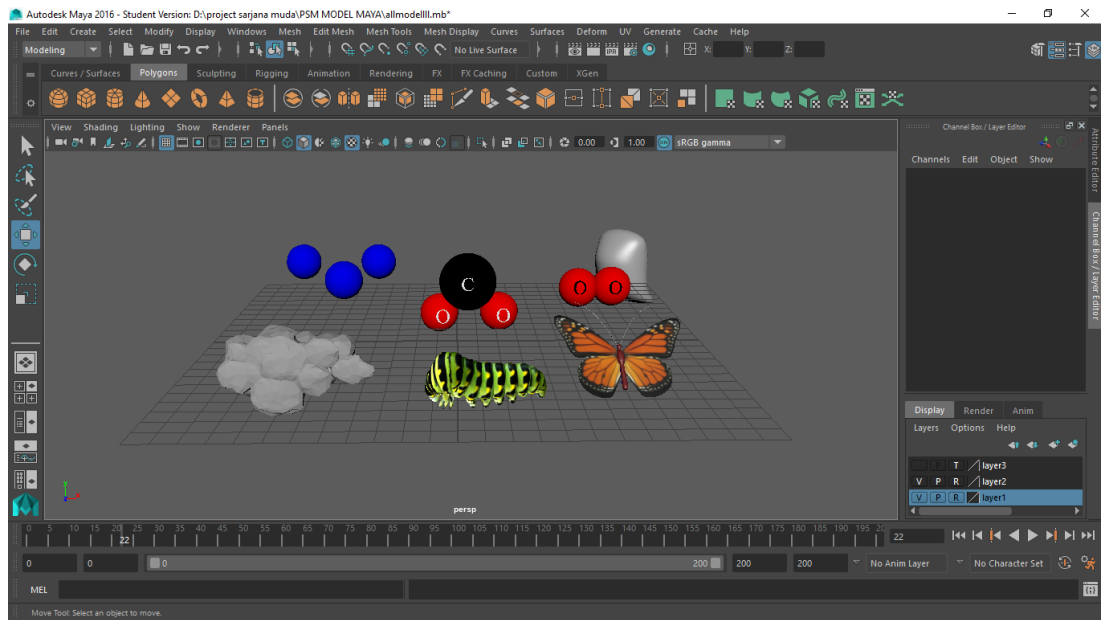


Figure 4.10 Create a 3D Model in Autodesk Maya 2016

4.2.3 Development of Application

After 3D assets needed are done, application can be developed using Unity software. Unity is one of software that used to develop application in this project because Unity can built the project in Android mobile application platform. Unity also can used to develop AR function with Vuforia SDK.

After download Unity software with suitable version as shown in Figure 4.11, Vuforia Software Development Kit (SDK) need to install with Unity (Figure 4.12). For the usable of AR Camera, a license key is needed to copy in AR camera configuration in the project. A licence key can be get in Vuforia Developer Portal in licence manager as shown in Figure 4.13.

After done the process, the development of project can be start in Unity software. All target marker and 3D model needed to import in Unity to create a AR enviroment as shown in Figure 4.14. After all the editing process is done, the project need to build into .apk file for mobile application which installed as Android platform smartphones as shown in Figure 4.15.

Accept terms

By clicking, I confirm that I am eligible to use Unity Personal per the [Terms of Service](#), as I or my company meet the following criteria:

- Do not make more than \$100k in annual gross revenues, regardless of whether Unity Personal is being used for commercial purposes, or for an internal project or prototyping.
- Have not raised funds in excess of \$100K.
- Not currently using Unity Plus or Pro.

If you are not eligible to use Unity Personal, please [click here](#) to learn more about Unity Plus and Unity Pro.

Download Installer for Windows

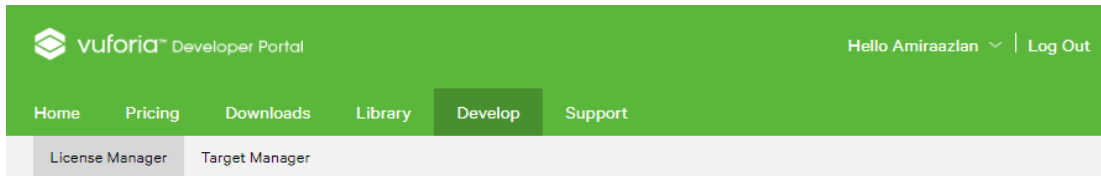
Download Unity Hub

Looking to download the installer for Mac OS X?
[Choose Mac OS X](#)

Figure 4.11 Download Unity Installer

The screenshot shows the Vuforia Developer Portal interface. At the top, there is a navigation bar with 'vuforia™ Developer Portal' on the left and 'Log In | Register' on the right. Below this is a secondary navigation bar with links for 'Home', 'Pricing', 'Downloads', 'Library', 'Develop', and 'Support'. Underneath, there are sub-links for 'SDK', 'Samples', and 'Tools'. The main content area is titled 'Vuforia Engine 7.5' and contains the following text: 'Use Vuforia Engine to build Augmented Reality Android, iOS, and UWP applications for mobile devices and AR glasses. Apps can be built with Unity, Android Studio, Xcode, and Visual Studio. As of Unity 2017.2, Vuforia Engine is delivered with the latest version of Unity. A legacy version of the Vuforia Unity Extension is provided to assist with project migrations.' Below the text are five download links, each with a platform icon and file size: 'Download for Android' (21.21 MB), 'Download for iOS' (26.95 MB), 'Download for UWP' (9.10 MB), 'Download Unity Extension (legacy)' (46.20 MB), and 'Download Unity'.

Figure 4.12 Download Vuforia SDK



License Manager > PSM_AR Science ap...

PSM_AR Science application [Edit Name](#) [Delete License Key](#)

[License Key](#) [Usage](#)

Please copy the license key below into your app

```
AfP3yWz/////AAABmWkz1ws0Xk97i3c9C31+ZcVGI3hfWe81mjM1
LDSeRN92PIkUp7LUQ7Lo9i6rv5J2l7AftGRYkDKmXtno9qrgPp5iS
P3KKfnlyZcHokLlmgTbV/40jtVr4qXSDEUQ8N/mjE52Fw9zMSgFq
6ZeJKvj6+q27n9bwVoOJcwK1viLHg1KLkNivAwo/j1TO0x2xiIhP
9+GzXO3h6oJ8xUBDh+oBW0NmXXw1keO1zMTgkG8J9ApqQ5K3BpH
yOeTqZ=xvqfH42h49ELgH0wB9061YxLjSdNOhEoDSSrikyHwnVCJ
00+zUfafwFOyETL2/fhPTTmed507a/L5JtbF9cKZQ10kZcdT+I6F
9TpOYMiX2355Tctv
```

Type: Develop

Status: Active

Figure 4.13 Create AR Science application license key

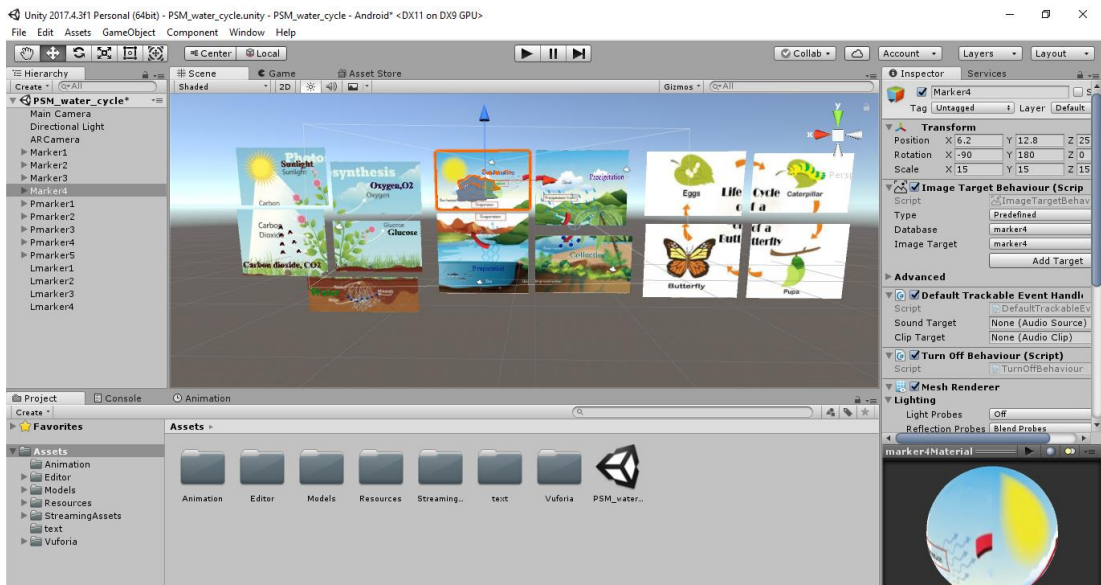


Figure 4.14 Editing AR camera scene in Unity

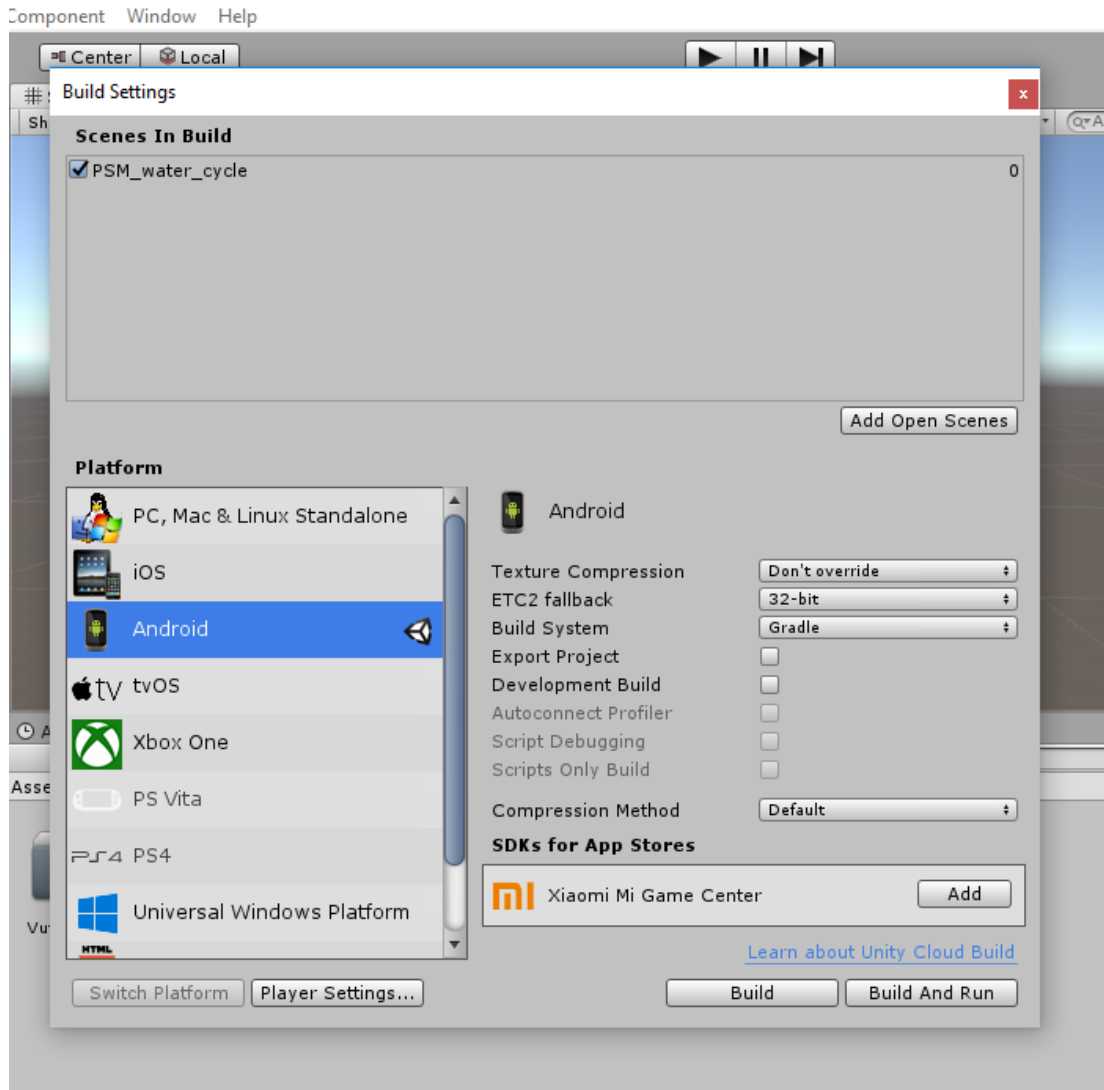


Figure 4.15 Built project into .apk file

4.2.4 Code Use in Unity

The language use in Unity software is C#. The script can be edit using MonoDeveloper that built-in external script editor in Unity. Figure 4.16 shows the code for play and stop the audio when marker is scan. Figure 4.17 shows the code for the audio will automatically plays when marker is tracked. Every markers have different types of audio that will be played. Figure 4.18 shows the code for audio stop when marker is stop scan.

```
7  |=====*/
8
9  |using UnityEngine;
10 |using Vuforia;
11 |using System.Collections;
12 |using System.Collections.Generic;
13
14 |namespace Vuforia
15 |{
16 |    /// <summary>
17 |    ///     A custom handler that implements the ITrackableEventHandler interface.
18 |    /// </summary>
19 |    public class DefaultTrackableEventHandler : MonoBehaviour, ITrackableEventHandler
20 |    {
21 |        //-----Begin Sound-----
22 |        public AudioSource soundTarget;
23 |        public AudioClip clipTarget;
24 |        private AudioSource[] allAudioSources;
25
26 |        //function to stop all sounds
27 |        void StopAllAudio()
28 |        {
29 |            allAudioSources = FindObjectsOfType(typeof(AudioSource)) as AudioSource[];
30 |            foreach (AudioSource audioS in allAudioSources)
31 |            {
32 |                audioS.Stop();
33 |            }
34 |        }
35 |        //function to play sound
36 |        void playSound(string ss)
37 |        {
38 |            clipTarget = (AudioClip)Resources.Load(ss);
39 |            soundTarget.clip = clipTarget;
40 |            soundTarget.loop = false;
41 |            soundTarget.playOnAwake = false;
42 |            soundTarget.Play();
43 |        }
44 |        //-----End Sound-----
45 |    }

```

Figure 4.16 Code for Plays and Stop the audio

```

133 //Play Sound, IF detect an target
134
135 if (mTrackableBehaviour.TrackableName == "marker1")
136 {
137     playSound("sounds/rain");
138 }
139
140 if (mTrackableBehaviour.TrackableName == "marker2")
141 {
142     playSound("sounds/marker2audio");
143 }
144
145 if (mTrackableBehaviour.TrackableName == "marker3")
146 {
147     playSound("sounds/marker3audio");
148 }
149 if (mTrackableBehaviour.TrackableName == "marker4")
150 {
151     playSound("sounds/marker4audio");
152 }
153 if (mTrackableBehaviour.TrackableName == "O2")
154 {
155     playSound("sounds/oxygenaudio");
156 }
157
158 if (mTrackableBehaviour.TrackableName == "water")
159 {
160     playSound("sounds/wateraudio");
161 }
162
163 if (mTrackableBehaviour.TrackableName == "CO2")
164 {
165     playSound("sounds/CO2audio");
166 }
167 if (mTrackableBehaviour.TrackableName == "Sunlight")
168 {
169     playSound("sounds/sunlightaudio");
170 }
171 }

```

Figure 4.17 Code for play audio when tracking found

```

172
173
174 protected virtual void OnTrackingLost()
175 {
176     var rendererComponents = GetComponentsInChildren<Renderer>(true);
177     var colliderComponents = GetComponentsInChildren<Collider>(true);
178     var canvasComponents = GetComponentsInChildren<Canvas>(true);
179
180     // Disable rendering:
181     foreach (var component in rendererComponents)
182         component.enabled = false;
183
184     // Disable colliders:
185     foreach (var component in colliderComponents)
186         component.enabled = false;
187
188     // Disable canvas':
189     foreach (var component in canvasComponents)
190         component.enabled = false;
191
192     Debug.Log("Trackable " + mTrackableBehaviour.TrackableName + " lost");
193
194     //Stop All Sounds if Target Lost
195     StopAllAudio();
196
197 }
198
199 #endregion // PROTECTED_METHODS
200 }
201

```

Figure 4.18 Code for stop all audio when tracking lost

4.3 APPLICATION INTERFACES

After the application is successfully installed on the device, the AR Science application can be open. A unity splash screen will appear on scene and followed by AR Science application screen.

4.3.1 Main Menu interfaces

Figure 4.19 shows the main menu interfaces for AR Science application. User need to click AR Camera button and it will directly navigate user to AR Camera interface. If user want to exit the application, then they can just click the Quit button.



Figure 4.19 Main Menu interface

4.3.2 AR Camera

AR Camera is the main part in this application. AR Camera allows user to be in augmented reality environment. User can see the virtual object appear from the target marker from AR Camera.

When user scan poster of Water Cycle process, user can view 3D model animation of Precipitation phase (marker1) as shown in Figure 4.20, Collection phase (marker2) as shown in Figure 4.21, Evaporation phase (marker3) as shown in Figure 4.22 and condensation phase (marker4) as shown in Figure 4.23.

When user scan poster Photosynthesis process, user can view 3D model animation of Oxygen process (marker5) as shown in Figure 4.24, Glucose process (marker6) as shown in Figure 4.25, water process (marker7) as shown in Figure 4.26, Carbon dioxide process (marker8) as shown in Figure 4.27 and sunlight process (marker9) as shown in Figure 4.28.

When user scan poster of Life Cycle of Butterfly process, user can view 3D model animation of Butterfly phase (marker10) as shown in Figure 4.29, Eggs phase (marker11) as shown in Figure 4.30, Caterpillar phase (marker12) as shown in Figure 4.31 and Pupa phase (marker13) as shown in Figure 4.32.

User also can hear the explanation audio in every target marker. The audio will be automatically play when marker is scanned.

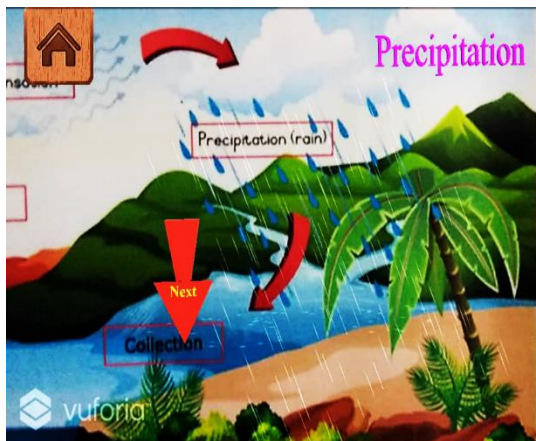


Figure 4.20 : AR Camera scan marker 1

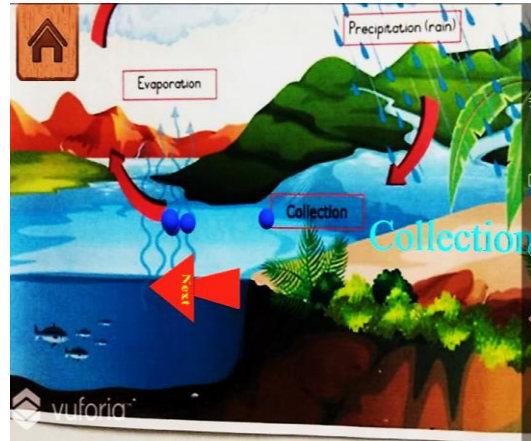


Figure 4.21 AR Camera scan marker 2

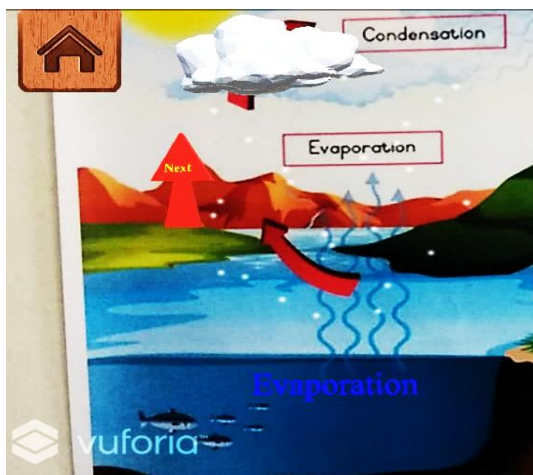


Figure 4.22 AR Camera scan marker 3



Figure 4.23 AR Camera scan marker 4

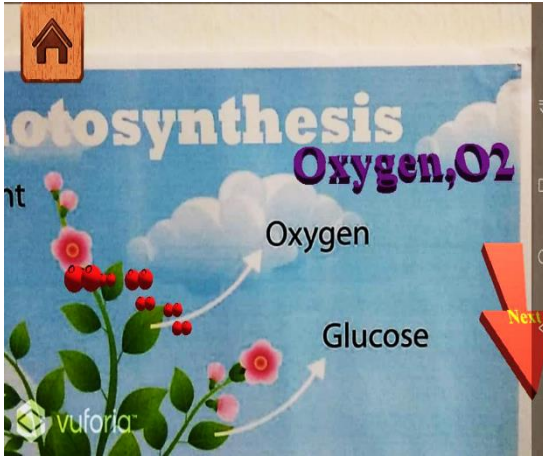


Figure 4.24 AR Camera scan marker 5



Figure 4.25 AR Camera scan marker 6

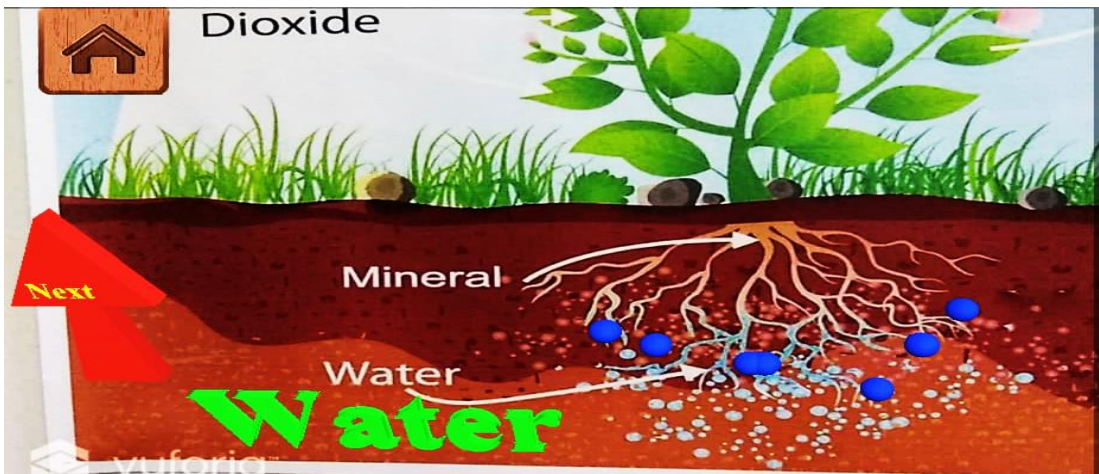


Figure 4.26 AR Camera scan marker 7

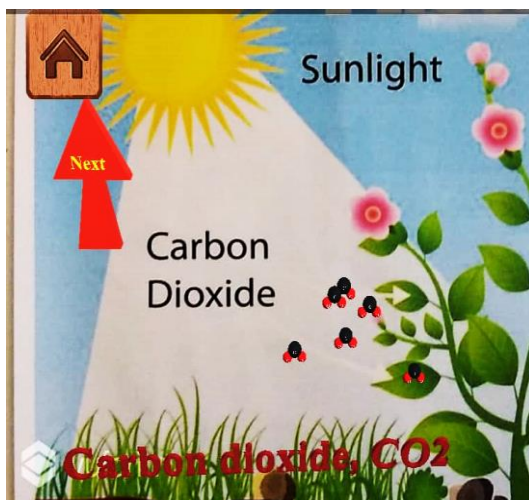


Figure 4.27 AR Camera scan marker 8



Figure 4.28 AR Camera scan marker 9



Figure 4.29 AR Camera scan marker 10



Figure 4.30 AR Camera scan marker 11

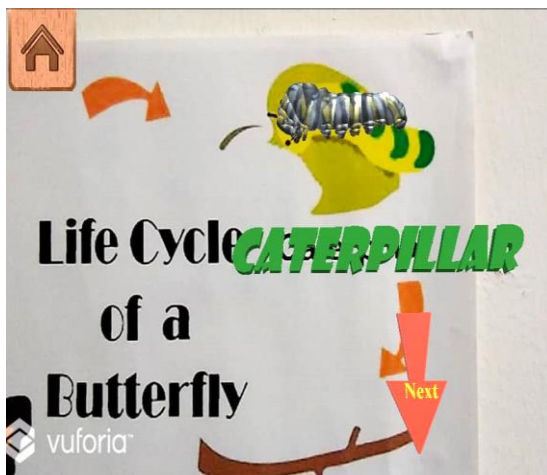


Figure 4.31 AR Camera scan marker 12



Figure 4.32 AR Camera scan marker 13

4.4 TESTING

After developing process is completed, the testing process is applied to evaluate the usability and effectiveness of the application. User Acceptance Test (UAT) Form is used to determine the application is fully test. A personal device (Huawei Media Pad 3) are used for the user to test the application. Testing process were conducted to 10 primary school students and a set of feedback form will be given to collect feedback towards the application (Appendix B).

4.4.1 Application Testing

This application was conducted to 10 primary school students. The Feedback Form will be given after the student test the application (Refer Appendix B). This form is to gather the feedback from the user after they used the application. Based on the responses, the findings shows that the range of user rating are between 3 (Agree) and 4 (Strongly Agree).

4.4.2 User Acceptance Testing

User Acceptance test is used to test every single of function of the AR Science application from beginning to end. Any errors occurs will be noted in this form. After the UAT have been distributed, the results show that all the tested function are pass. These UAT can refer to Appendix A.

4.5 RESULT AND DISCUSSION

Figure 4.32 shows the findings of user feedback after using AR Science application. There are 10 numbers of student answer the feedback form. They need to rate the question based on the scale strongly disagree, disagree, neutral, agree and strongly agree. Based on the result in the graph, 80% students rate strongly agree as they like and enjoy use the application and 20% students rate for agree. There are 70% students are strongly agree that they gain information and help in understanding after used the application while 30% students rate as agree. All student rate strongly agree to use the application again and want to have the application. The mean of the result is 4.83. So, we can conclude that the student give a positive feedback toward the application.

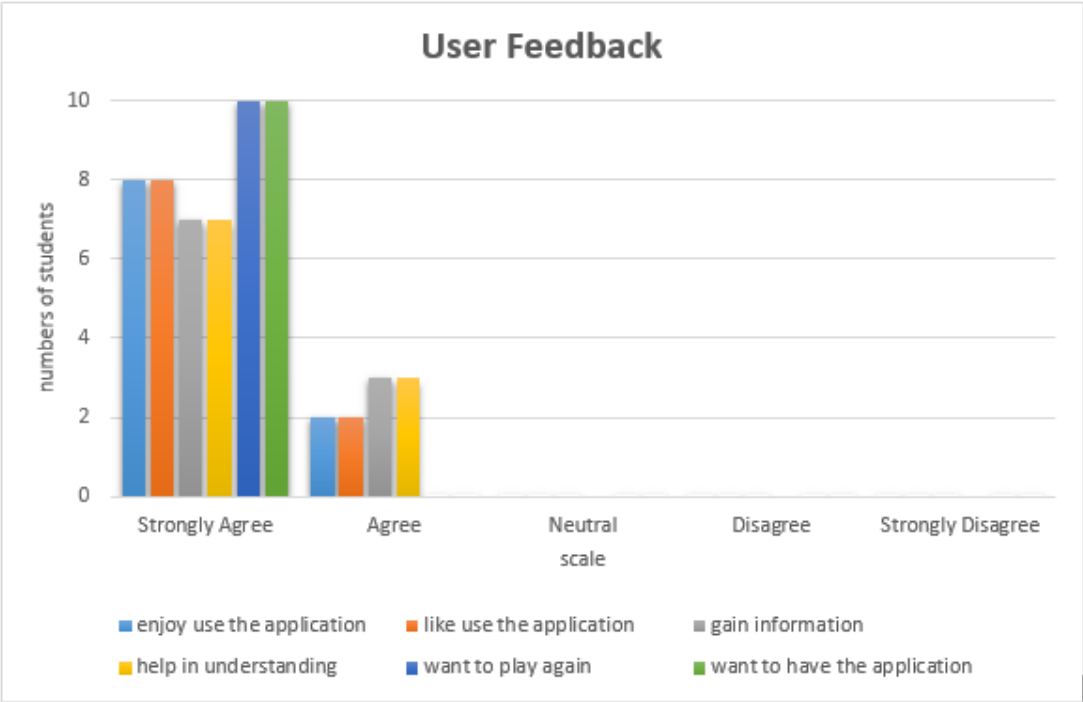


Figure 4.32: Summary of user feedback

4.6 USER MANUAL

User manual had been produced after completed the implementation of the application. User manual is a document that able to give step by step guidance for user on how use the system. The user manual for AR Science application can be refer to Appendix C.

CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

Chapter 5 will discuss the summarization of finding of developing an augmented reality science application for primary school students in order to achieve the objectives and overcome the problems that have been stated in problem statement in Chapter1. In young age of education, students have trouble in understand the abstract science concept. This application can serve as an effective tool to gain more understanding since it have rich multimedia element such as animation, audio and graphic. Therefore students can learn with fun using this application. Software used to develop this application is Unity, Vuforia and Autodesk Maya. This application is developed by follow ADDIE methodology which can reduce a lot of time and cost development. This application is implemented and evaluated by primary school students to test the effectiveness and functionally of this application. The evaluation process shows the students give positive feedback and this application meet the objectives of the application.

5.2 RESEARCH CONSTRAINT

The constraint in this project are:

i) Limitation of Time

The limited time causes limited topic can be covered in Augmented Reality Science application. Only 3 topics are covered in this project which are Water Cycle Process, Photosynthesis process and Life Cycle of Butterfly only.

ii) Low rating quality markers in Vuforia

Markers uploaded in Vuforia Developer Portal need a good quality. If the markers uploaded not achieve 2 star, the AR camera cannot detect it accurately. Therefore, the markers uploaded need to have a good quality.

iii) Single markers trackers only

In this project, one markers only can track at a time in every poster. It is due to audio in every markers are automatically played if markers are detect. If multiple marker track at one time, all audio will be play together at one time.

5.3 FUTURE WORK

There are several enhancements that can be applied for future improvement of Augmented Reality Science application for primary school students.

- i. Developer has to implement the Augmented Reality Science application with mobile platforms that support in Android and iOS version.
- ii. Developer has to provide more topic in science subject to covered in the Augmented Reality Science application. So students can learned more topic using Augmented Reality technology.
- iii. Developer has to provide music or video for students can sing, so they will be more fun and enjoy while learning.

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APPENDIX A

USER ACCEPTANCE TEST (UAT)

TABLES OF CONTENTS

1.0 TESTING REPORT

1.1 Main Menu

1.2 Marker Water Cycle Poster

1.3 Marker Photosynthesis Poster

1.4 Marker Life Cycle of Butterfly Poster

2.0 SYSTEM TESTING APPROVAL

1.0 TESTING REPORT

The purpose of this section is to outline the User Acceptance Testing (UAT) process for the application. Approval of this testing that reviewers are confident that following the execution of the test plan, the resulting system will be considered fully tested and eligible for implementation.

Teacher of primary school, Cik Nor Ashlia binti Saidi was selected to go through each of the instructions in the user manual. Any errors or problems found are noted on this form.

1.1 Main Menu

Table 1.1 shows the test case for main menu interfaces. All the results are pass.

Table 1.1 Main Menu interfaces test case

Event	Test Data	Expected Result	Actual Result	Pass /Fail	Comment
Single tap AR Camera	User go to AR Camera page when tap the AR Camera button.	User will succeed go to AR Camera interface.	User succeed go to AR Camera interface.	Pass	-
Single tap Quit	User exit the application when tap the Quit button	User will succeed close the application.	User succeed close the application	Pass	-

1.2 Marker Water Cycle Poster

Table 1.2 shows the test case for marker1, markers2, markers 3, markers 4 in Water Cycle Poster. All the result is pass.

Table 1.2 Water Cycle Poster test case

Event	Test Data	Expected Result	Actual Result	Pass /Fail	Comment
Scan marker 1 (Precipitation phase)	User can view Precipitation animation when scan the marker 1.	The Precipitation animation will play.	The Precipitation animation played.	Pass	-
Scan marker 2 (Collection phase)	User can view Precipitation animation when scan the marker 2.	The Collection animation will play.	The Collection animation will played.	Pass	-
Scan marker 3 (Evaporation phase)	User can view Evaporation animation when scan the marker 3.	The Evaporation animation will play.	The Evaporation animation played.	Pass	-
Scan marker 4 (Condensation phase)	User can view Condensation animation when scan the marker 4.	The Condensation animation will play.	The Condensation animation played.	Pass	-

Single Audio	User can hear the audio when scan to every target marker.	The audio will automatically play.	The audio automatically played.	Pass	-
--------------	---	------------------------------------	---------------------------------	------	---

1.3 Marker Photosynthesis Poster

Table 1.3 shows the test case for marker5, markers6, markers 7, markers 8, marker 9 in Photosynthesis Poster. All the result is pass.

Table 1.3 Photosynthesis Poster test case

Event	Test Data	Expected Result	Actual Result	Pass /Fail	Comment
Scan marker 5 (Oxygen)	User can view oxygen animation when scan the marker 5.	The oxygen animation will play.	The oxygen animation played.	Pass	-
Scan marker 7 (Glucose)	User can view glucose animation when scan the marker 7.	The glucose animation will play.	The glucose animation played.	Pass	-
Scan marker 8 (water)	User can view water animation	The water animation will play.	The water animation played.	Pass	

	when scan the marker 8.				
Scan marker 9 (Carbon dioxide)	User can view Carbon dioxide animation when scan the marker 9.	The Carbon dioxide animation will play.	The Carbon dioxide animation played.	Pass	-
Single Audio	User can hear the audio when scan to every target marker.	The audio will automatically play.	The audio automatically played.	Pass	-

1.4 Marker Life Cycle of Butterfly Poster

Table 1.4 shows the test case for marker10, markers11, markers 12, markers 12, in Life Cycle of Butterfly Poster. All the result is pass.

Table 1.4 Life Cycle of Butterfly Poster test case

Event	Test Data	Expected Result	Actual Result	Pass /Fail	Comment
Scan marker 10 (Butterfly phase)	User can view butterfly animation when scan the marker 10.	The butterfly animation will play.	The butterfly animation played.	Pass	-

Scan marker 11 (Eggs phase)	User can view eggs animation when scan the marker 11.	The eggs animation will play.	The eggs animation will played.	Pass	-
Scan marker 12 (Caterpillar phase)	User can view caterpillar animation when scan the marker 12.	The caterpillar animation will play.	The caterpillar animation played.	Pass	-
Scan marker 13(Pupa phase)	User can view pupa animation when scan the marker 4.	The pupa animation will play.	The pupa animation played.	Pass	-
Single Audio	User can hear the audio when scan to every target marker.	The audio will automatically play.	The audio automatically played.	Pass	-

2.0 SYSTEM TESTING APPROVAL

General Information		
Project Name	Engaging Learning with Augmented Reality for Primary School Science Education	
Time Taken	9 Months	
Client	Cik Nor Ashlia bin Saidi (Teacher)	
Application Name	AR Science application	
	Name	Date
Verified by: <hr/> Developer	NUR AMIRA BAIDURI BT AZLAN	
Approved by : <hr/> Client	NOR ASHLIA BT SAIDI	

APPENDIX B






USABILITY TEST (QUESTION FOR USER)

Augmented Reality Science Application

Following the study, each student was asked to rate one six short and simple questions. As the participants were young children, a smiley face-based was used as it is fun and easy to complete. For the survey, the experimenter read the question and the participant tick the appropriate column.

* Required

1. Do you like this AR Science application? *

	
<input type="radio"/> Strongly Disagree	<input type="radio"/> Disagree
	
<input type="radio"/> Neutral	<input type="radio"/> Agree
	
<input type="radio"/> Strongly agree	

2. Do you enjoy this AR Science application? *



Strongly Disagree



Disagree



Neutral



Agree



Strongly agree

3. Do you gain information when using this AR Science application? *



Strongly Disagree



Disagree



Neutral



Agree



Strongly agree

4. Do you think AR Science application help in understanding in science subject? *



Strongly Disagree



Disagree



Neutral



Agree



Strongly agree

5. Do you want to play AR Science application again? *



Strongly Disagree



Disagree



Neutral



Agree



Strongly agree

6. Do you want to have AR Science application? *



Strongly Disagree



Disagree



Neutral



Agree



Strongly agree

APPENDIX C

USER MANUAL FOR AR SCIENCE APPLICATION

TABLES OF CONTENT

1.0 GENERAL INFORMATION

1.1 System Overview

2.0 SYSTEM SUMMARY

2.1 System Configuration

3.0 GETTING STARTED

3.1 System Menu

3.1.1 Main Menu

3.1.2 AR Camera

1.0 GENERAL INFORMATION

1.1 System Overview

AR Science application is the application for primary school students. This application is developed to help students in learn science subject. This application is designed based on the topics in the syllabus science subject for primary school students. It is well designed as an interactive application that can gain more understanding on topics learned.

2.0 SYSTEM SUMMARY

2.1 System Configuration

AR Science application operates on mobile devices with Android operating system. It is compatible with Android 4.1 'Jelly Bean' (API Level 16 or higher versions). The applications doesn't require any Internet connection to use.

3.0 GETTING STARTED

3.1 System Menu

3.1.1 Main Menu

Main Menu will be appearing after the AR Science application is run. Figure 1 shows main menu interfaces in AR Science Application. Table 1 shows the description main menu interface.



Figure 1 Main Menu interfaces

Table1 Main menu interface description

Function	Description
A1	Application name
A2	Navigate to AR Camera
A3	Exit the AR Science application

3.2.2 AR Camera

3.2.2.1 Poster Water Cycle

This pages will displays the water cycle process. Figure 2 shows Poster water cycle scan in AR Science Application. Table 2 shows the description of poster water cycle scan.

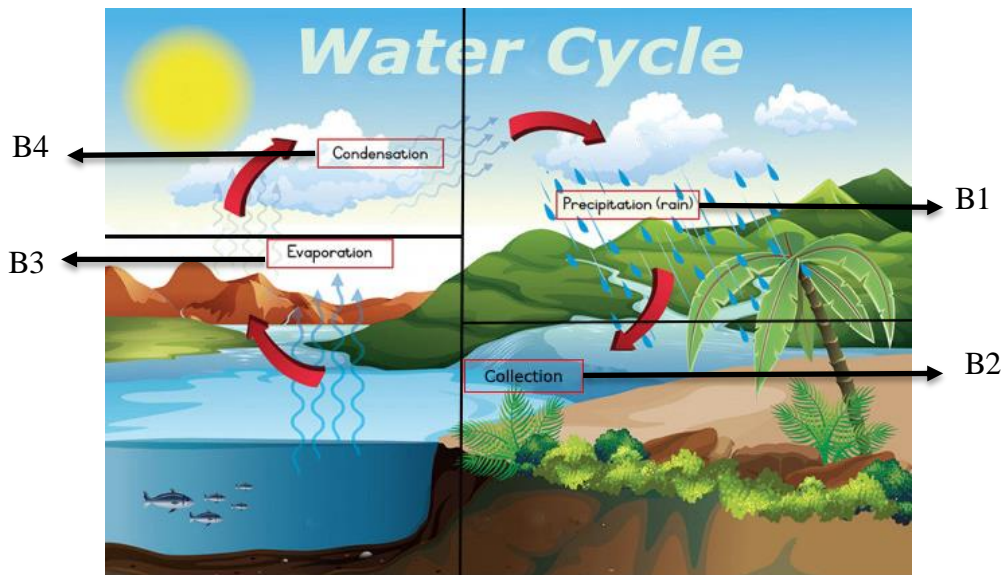


Figure 1 Poster water cycle scan

Table 5.5 Poster water cycle scan description

Function	Description
B1	Displays 3D animation of Precipitation phase
B2	Displays 3D animation of Collection phase
B3	Displays 3D animation of Evaporation phase
B4	Displays 3D animation of Condensation phase

3.2.2.2 Poster Photosynthesis

This pages will displays the photosynthesis process. Figure 3 shows Poster photosynthesis scan in AR Science Application. Table 3 shows the description of poster photosynthesis scan.

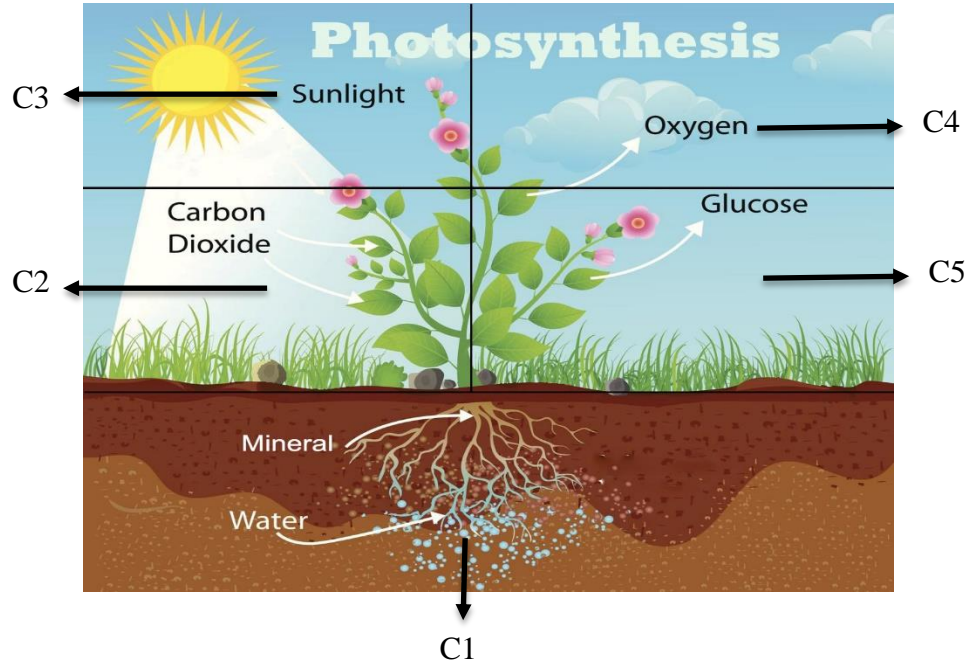


Figure 2 Poster photosynthesis scan

Table 5.6 Poster photosynthesis scan description

Function	Description
C1	Displays 3D animation of water process
C2	Displays 3D animation of water carbon dioxide process
C3	Displays 3D animation of sunlight process
C4	Displays 3D animation of oxygen process
C5	Displays 3D animation of glucose process

3.2.2.2 Poster Life Cycle of Butterfly

This pages will displays the life cycle of butterfly process. Figure 4 shows Poster life cycle of butterfly scan in AR Science Application. Table 4 shows the description of poster life cycle of butterfly scan.

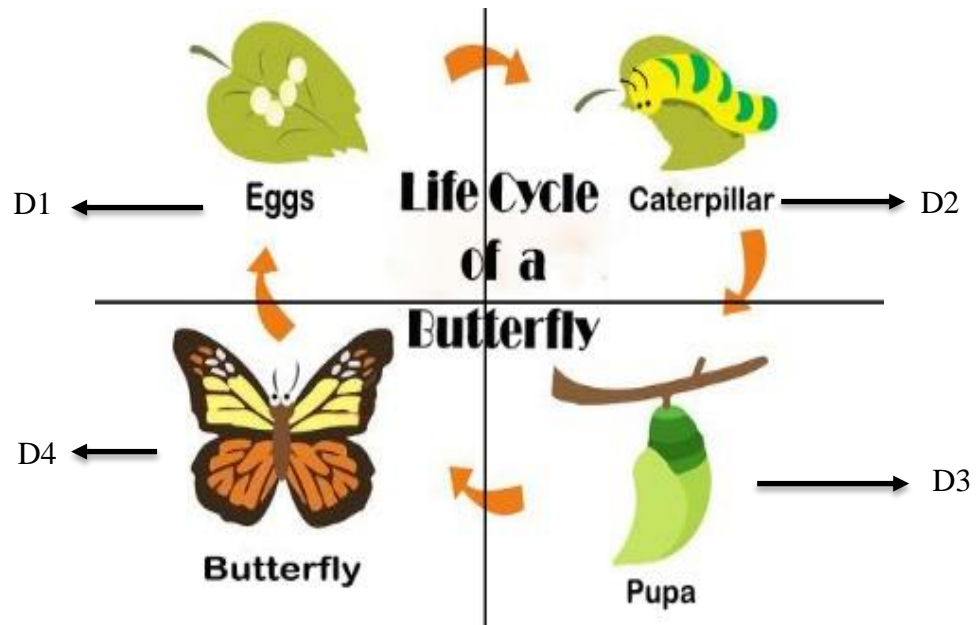


Figure 3 Poster life cycle of butterfly scan

Table 5.7 Poster life cycle of butterfly scan description

Function	Description
D1	Displays 3D animation of eggs phase
D2	Displays 3D animation of caterpillar phase
D3	Displays 3D animation of pupa phase
D4	Displays 3D animation of butterfly phase