AUGMENTED REALITY MODEL FOR PRESCHOOL LEARNING

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Abstrak

Subjek sains amat penting untuk membina pengetahuan saintifik di kalangan pelajar. Di Malaysia, perlaksanaan Kurikulum Sains dilaksanakan melalui pendekatan konvensional. Bagaimanapun, pendekatan ini kurang menarik minat pelajar dalam meneroka ilmu pengetahuan dengan lebih meluas. Di samping itu, pelajar hanya mempelajari pengetahuan asas tanpa dapat menggambarkan isi kandungan pelajaran tersebut. Justeru itu, kajian ini bertujuan untuk mengaplikasikan teknologi Realiti Tambahan (AR) dalam pengajaran dan pembelajaran subjek Awal Sains untuk menangani isu tersebut. AR ialah penambahan pada dunia nyata melalui penambahan objek maya tiga-dimensi (3D). Ini terbukti bahawa AR adalah satu kaedah yang berkesan dalam menyampaikan pengajaran kepada pelajar berbanding dengan kaedah konvensional. Kajian ini mengaplikasikan AR di prasekolah bagi subjek Awal Sains yang memfokuskan kepada organ dalaman manusia yang dikenali sebagai Sistem Otot. Kajian ini disesuaikan dengan teori Model Pembelajaran Berasaskan Pengalaman (ELM) untuk membina model keperluan Realiti Tambahan bagi Pembelajaran dalam Sistem Otot (ARMS). Model yang dicadangkan mengandungi tiga (3) komponen; i) Keperluan Melaksanakan AR di Kelas (R-IARC), ii) Prototaip Aras Tinggi (HLP) dan iii) ELM. Metodologi kajian inAi melibatkan lima (5) fasa utama; i) kajian teori, ii) kajian awal, iii) pembinaan model keperluan, iv) pembangunan ARMS, dan v) penilaian model oleh pengguna serta pakar yang berkaitan. Keperluan model yang dicadangkan diperolehi melalui teknik carian fakta iaitu temu bual, pemerhatian, dan semakan dokumen. Model yang dicadangkan telah disahkan dengan menggunakan pendekatan prototaip. Penilaian terhadap prototaip ini telah dilaksanakan melalui penilaian pakar dan pengguna akhir yang terlibat. Hasil penilaian menunjukkan penggunaan ARMS sangat berkesan untuk dilaksanakan dalam pengajaran dan pembelajaran subjek Awal Sains. Ini kerana ia mampu untuk menerangkan topik yang sukar. Di samping itu, ia juga membuktikan integrasi teknologi AR dalam pengajaran dan pembelajaran dapat mewujudkan persekitaran yang menyeronokkan kerana sokongan penggunaan visual maya objek 3D. Hasilnya, pelajar boleh memahami dan mengenali fungsi, tip kesihatan dan penyakit yang berkaitan dengan sistem otot melalui ARMS. Kajian ini juga mendapati bahawa pelaksanaan ARMS mampu meningkatkan pembangunan kognitif pelajar dan meningkatkan kebolehan pembelajaran pelajar.

Kata kunci: AR, keperluan model, ARMS, pendidikan prasekolah, Awal Sains

Abstract

Science subject is very important to create scientific knowledge among students. In Malaysia, the implementation of the Science Curriculum is normally done via conventional approach. However, this approach is not able to attract students' interests in exploring more knowledge. In addition, the students only acquire the basic knowledge without being able to visualize the subject matters. Thus, this study is aimed to apply Augmented Reality (AR) technology in teaching and learning of the Basic Science subject to overcome the issues. AR is the augmentation of the real world through the addition of three-dimensional (3D) virtual objects. AR has been proven as an effective method in delivering lessons to the students compared to conventional method. This study applied AR in preschool Basic Science subject that focused on the internal organ of human body known as the Muscular System. This study adapted AR with Experiential Learning Model (ELM) theory to construct the requirement model of the Augmented Reality for Learning in Muscular System (ARMS). The proposed model consisted of three (3) main components; i) Requirement to Implement AR in a Classroom (R-IARC), ii) High-Level Prototyping (HLP), and iii) Experiential Learning Model (ELM). The methodology in this study involved five (5) main phases; i) theoretical study, ii) preliminary study, iii) requirement model construction, iv) ARMS development, v) model evaluation by users and experts respectively. The requirement of the proposed model was collected using multiple facts finding techniques, namely interview, observation, and document reviews. The proposed model was validated using prototyping approach. The evaluation of the prototype was done by expert reviews and end-user acceptance study. The results of the evaluation showed that the ARMS was highly effective to be implemented in the teaching and learning of Basic Science subject. This is because it assists in explaining difficult topics. In addition, it has also been proven that the integration of the AR technology in teaching and learning is able to create an enjoyable environment because it is supported by the visualization of 3D virtual objects. As a result, the students were able to understand and recognize the functions, health, and diseases of the muscular system through ARMS. The study also found that the implementation of ARMS was able to increase the students' cognitive development and enhance the students' learning ability.

Keywords: AR, requirement model, ARMS, preschool education, Basic Science

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List of Abbreviations

AC	Abstract Conceptualization
AE	Active Experimentation
ALE	Augmented Learning Environment
AR	Augmented Reality
ARMS	Augmented Reality for Learning in Muscular System
CD	Compact Disk
CE	Concrete Experience
ELM	Experiential Learning Model
HLP	High-Level Prototyping
HMD	Head Mounted Display
MoE	Ministry of Education
R-IARC	Requirement to Implement AR in Classroom
RO	Reflect Observation
VE	Virtual Environment
VR	Virtual Reality
VRML	Virtual Rality Modelling Language

CHAPTER ONE
INTRODUCTION

1.1 Overview

This chapter discusses the background of the study which is followed by the problem statement, research questions, research scope, theoretical frameworks, lists of significant and contribution of this study. Lastly, the definitions of the terminologies used throughout this study are presented.

1.2 Background

The ability to superimpose real-time computer animation onto the real world is commonly known as Augmented Reality (AR). AR differs from Virtual Reality (VR) where it requires real-time markers for it to function. It allows the merging of virtual information with the real environment to provide users with more immersive interaction with their surroundings. Unlike other computer animations, AR provides a new experience of the real world which draws the users away from the real world and onto the screen (Hainich, 2006).

The potential of AR technology is growing rapidly and it had been applied in many fields not limited to engineering (Webster, Feiner, MacIntyre, Massie, & Krueger, 1996), medicine (Li, 2005) and military (Julier, Baillot, Lanzagorta, Brown, & Rosenblum, 2001) but also in education (Billinghurst, 2002). Thus, this research is conducted especially for education, particularly for preschool students in the Basic Science subject in which one of the topics is human body. As mentioned by Zainun

(2006), the topic of human body is interesting and a rewarding knowledge for the young children.

Furthermore, various interactive websites for the teaching and learning of internal organs have been developed to introduce children the importance of learning the basics of human organs. Malaysian preschool syllabus of Basic Science covers only the basics of the human body, the functions and health. Table 1.1 provides few examples of existing interactive websites, specifically for teaching and learning human body to children.

Table 1.1: Educational Anatomy Website Reviews for Kids

Site	**Description**	**URL**
Discovery Channel: The Human Body Learning Experience	Interactive activities about the Human Body using movie concept	http://dsc.discovery.com/tv/human-body/explorer/explorer.html
VirtualBody	Tour the Human Brain, the Skeleton, the Human Heart, the Digestive Trace of the human body through animated graphics	http://www.medtropolis.com/VBody.asp
BBC: The Human Body	An excellent resource on each system of the human body, including interactive activities	http://www.bbc.co.uk/science/humanbody/
Kids Health	How the body works	http://kidshealth.org/kid/htbw/htbw_main_page.html
BAM! Your Body	Develop by Department of Health and Human Services: Center for disease control and prevention.	http://www.bam.gov/sub_yourbody/index.html

Malaysia has planned effective strategies for teachers' teaching and learning approach using computers (Zahari, 2009). According to the statistics by the Ministry of Education (MoE) in Educational Development Report 2001-2010 pages 2-19, all primary schools are supplied with Information and Communication Technology (ICT) equipment including the computer equipment and hardware. The goal of MoE is providing computer lab equipment to all government schools including preschools, primary and secondary schools to improve the teaching and learning approach (MoE, 2001). Based on the report of Education Development Master Plan 2001-2010, the following ICT projects have been implemented:

1. The preparation facility and the school of computing project (Computer Laboratory)
2. The provision of broadband access SchoolNet
3. Smart School Pilot Project
4. Teaching and Learning in English
5. Educational TV Programme

However, teaching and learning science is not an easy process. Some issues related to this process are:

1. The importance of science subject

   Science plays an important role in our lives. In Malaysia, science is a core subject in the primary and secondary schools' curriculum. The main aim of teaching science to primary students is to introduce a foundation for building a society in the aspects of life, physical, material, earth and world of technologies (Sharifah, 2003). Therefore, the preschool level should cover these aspects before proceeding to the higher levels of education.

2. Difficulties in learning science subject

   Currently, in many cases students feel that science is one of the most difficult subjects (Nani & Rohani, 2003) to learn and understand (Norjihan, Norhana, & Noor, 2006). According to Norjihan et al. (2006), some of the teachers use learning techniques which are outdated and they generally use one-way communication for teaching and delivering information. As a result, students just receive information and these are some of the reasons why students feel bored and depressed in learning science (Norjihan et al., 2006).

   Based on the interviews conducted, there were several methods used by teachers to teach the subject. Most of the common paper-based methods include drawing, picture charts, word cards, puzzles, exercises, worksheets, following the teacher's movement, and singing. However, the technology method related approach is still limited. Currently, most of the teachers used Compact Disk (CD) to support their teaching and learning process. Thus, the teacher found that this conventional method had some constraints especially when a certain topic needs to be explained.

   Human anatomy is one of the topics related to Basic Science subject. The topic covers the explanation of the basic functions of the external and internal body. The students have been introduced to the basic functions of external body only. Therefore, this study aims to improve the existing teaching aids by using AR technology.

3. Lack of interactive support tools in teaching and learning science subject

   Nowadays, teachers and students use ICT and various types of software in teaching and learning sessions. The motive of using the technology approach as a learning aid is to create more effective, interesting and fun learning environment (Augustine, 2006; Robiatul & Halimah, 2010).

   Previous studies have proven that the use of AR as a support tool is able to increase the students' interest (Balog, Pribeanu, & Iordache, 2007; Lamanauskas, Pribeanu, Vilkonis, Balog, Iordache, & Klangauskas, 2007; Pérez-López, Contero, & Alcañiz, 2010), motivation (Pérez-López et al., 2010), easy to understand (Balog et al., 2007; Juan, Beatrice, & Cano, 2008), intuitive (Billinghurts, 2002), effective (Liarokapis & Anderson, 2010), attractive (Lamanauskas et al., 2007), and fun (Bruce, 1997; Martin, Sexton, Franklin, Gerlovich, & McElroy, 2009). In addition, the implementation of AR in educational environment is also cost-effective (Billinghurst, 2001; Min-Chai & Jiann-Shu, 2008; Liarokapis & Anderson, 2010). Through AR implementation in the classroom, students can visualize the virtual object related to the subject matter and this application is able to attract students' attention (Billinghurst, 2002). Thus, AR can be accepted as an innovative support tool in teaching and learning science subject. As a result, this implementation can achieve the objective of introducing science subject to preschool students in a more attractive way compared to the conventional approach such as through the use of textbooks as static information and two-dimensional (2D) image display. Hence, students can improve and develop their science knowledge.

Thus, this study aims to develop a model which conceptualizes how AR could be used to support cognitive development in children's learning environment, which focuses on the Basic Science subject.

1.3 Problem Statement

Science is a very important subject in school curriculum to create the scientific knowledge among students. Nevertheless, it is obvious that learning science via conventional method is not making the knowledge any easy to learn and understand. According to Wang and Woo (2007), integrating technology into teaching and learning as a support tool has a great potential to improve students' learning outcomes and effectiveness. However, based on the interviews conducted, the study found that preschool teachers just used Compact Disc (CD) as a technology-based support tool, which failed to attract students' attention. Thus, this study proposed AR to solve the aforementioned problem.

Many studies related to the use of AR for human anatomy learning were carried out (Shuhaiber, 2004; Juan et al., 2008; Pérez-López et al., 2010). However, the implemented AR for the human body topic was mostly focused on the primary (Juan et al., 2008; Pérez-López et al., 2010), secondary and higher (Shuhaiber, 2004; Chien, Chen, Jeng, 2010) education levels. Based on the literature, this study did not find the teaching and learning of muscular system using AR in the preschool level yet. In addition, the topic of muscular system was suggested by the expert teachers because the internal organs are difficult to visualize with the limited support tools.

1.4 Research Questions

This research aims to answer the following questions:

1. What are the requirements used as consideration for AR implementation in learning environment?
2. How can the development of AR application be simplified?
3. What are the quality criteria needed to be considered for developing an effective learning support tool for preschool students?

1.5 Research Aim and Objectives

The aim of this study is to design a requirement model for AR implementation in the Basic Science subject learning that is able to support the cognitive development among preschool students. In order to achieve this aim, the following objectives have been defined:

1. To specify the AR requirement for developing learning support tool.
2. To construct a requirement model based on the identity of the main components.
3. To evaluate the proposed AR application based on the identified criteria.

1.6 Research Scope

This study focuses on Basic Science subject specifically in the topic of a human body for a preschool level. However, this study aims to introduce and emphasize the importance of internal organs. This study introduces one of the important internal organs known as muscular system. There are three kinds of muscle; namely i) smooth, ii) cardiac, and iii) skeletal.

This research involves teachers and preschool students as respondents. The study has identified teachers as the expert respondents who have been teaching the Basic Science subject for more than ten years at five preschool schools in Jitra, Kedah.

1.7 Theoretical Framework

The purpose of theoretical framework in this study is to identify the relationships between theories and research as a guideline to define the implications of theories on the research conducted (Norshuhada & Shahizan, 2010). The theoretical framework in this study presents the three theories to support and conduct this research work. The three theories are Piaget's Cognitive Development Theory, Multimedia Learning Theory, and Experiential Learning Model (ELM). These theories were used to analyze the preschool characteristics associated with their cognitive development process. These theories are described as below:

1. Piaget's Cognitive Development Theory: This theory is applied to recognize the characteristics of the children in this study.

2. Multimedia Learning Theory: This study adopts four principles in integrating and supporting the Augmented Reality for Learning Muscular System prototype and exercise provided. The principles consist of coherence, spatial contiguity, multimedia, and voice. The four principles are also used to construct measurement instrument for evaluating the qualities of acceptance, which consists of visualization, effectiveness, efficiency, fun and entertainment.

3. ELM: This study applies ELM to develop the students' skills based on their thinking, feeling, doing, and watching process. Therefore, ELM is also used to measure the acceptance of Augmented Reality for Learning Muscular System as a support tool in Basic Science subject.

As shown in Figure 1.1, the theoretical framework structures visualize the relationships between cognitive development, learning theory, and learning style to support learning Basic Science using AR.

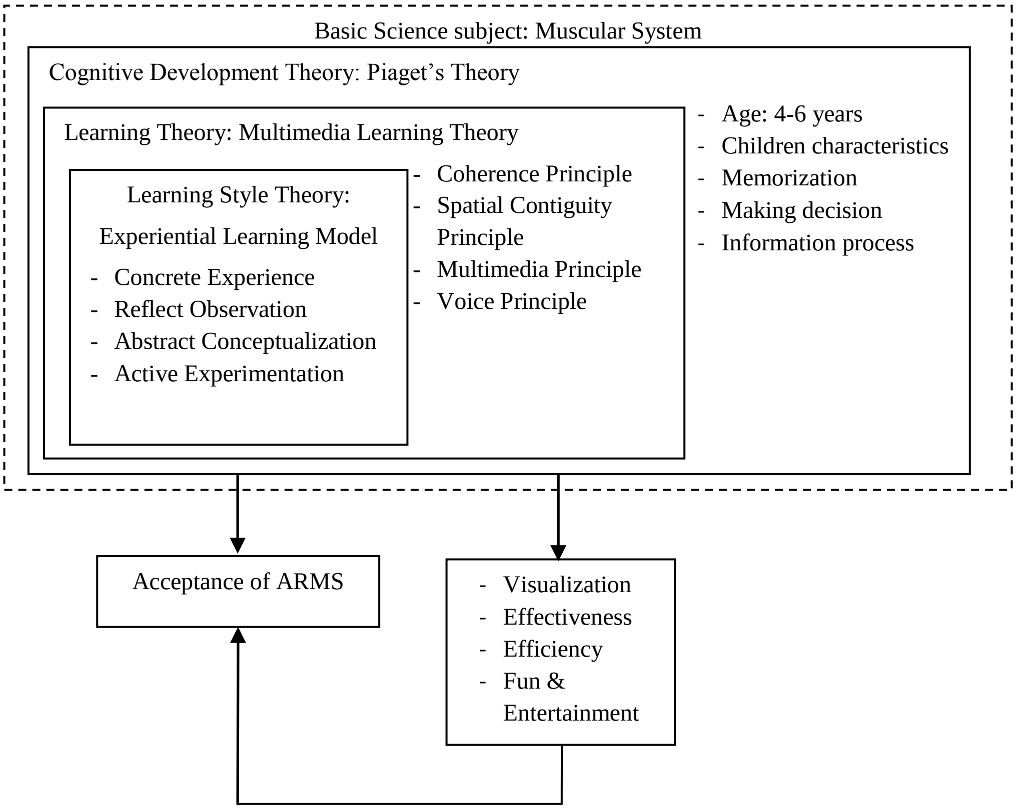


Figure 1.1: Theoretical Framework

1.8 Significance of the Study

This research constructs a requirement model and develops a prototype for the muscular system. There are two categories of significance; body of knowledge and stakeholder.

1. Body of knowledge

    a. The Basic Science subject: This study focuses on the topic of a human body. This is an interesting topic for students. The preschool students are familiar with their individual bodies through a formal and informal education. However, preschool students are not exposed to human internal organs. The Augmented Reality for Learning Muscular System introduces one of the most important human internal organs known as a muscular system. It has added valuable information for the preschool students.

b. Cognitive development theory: This study focuses on the topic of a human body. This is an interesting topic for students. preschool students were familiar with their individual bodies through a formal and informal education. However, preschool students are not exposed to human internal organs. The Augmented Reality for Learning Muscular System introduces one of the most important human internal organs known as a muscular system. It has added valuable information for the preschool students.

2. Stakeholder

a. The students: Learning using AR technology would promote students' creative thinking and improve their understanding of human body topic. AR is able to provide an exciting tool for the preschool students to learn new things in more interesting ways. It makes the Basic Science subject interesting, enjoyable, and meaningful to preschool students. It is considered as a support tool to address their problems as previously mentioned in the statement of problem.

b. The teachers: This study is to assist the preschool teachers in diversifying their pedagogical tools. Using AR technology, it would make the teaching and learning sessions more attractive and effective than the traditional approach. This tool is helpful to explain the difficult parts in Basic Science subject. Thus, it improves the quality of teaching.

c. Researchers and developers: It is hoped that the requirement model for Augmented Reality for Learning Muscular System will be a platform for other researchers or developers to design AR application for the future. Hence, they will help to enhance the technology applications in the academic area especially for the preschools in Malaysia.

1.9 Contributions of the Study

This research makes a number of research contributions to the current state of education in Malaysian preschools using AR as a learning tool. The outcome of the study presents the following contributions for the AR in education technology area:

1. Requirement Model for Augmented Reality for Learning Muscular System: The purpose of requirement model for Augmented Reality for Learning Muscular System and integration of these theories are able to create the cognitive learning of Basic Science subject in preschools. The requirement model for Augmented Reality for Learning Muscular System can be a reference requirement model for other researchers or developers to design

AR application for the preschool level. Thus, it helps to enhance technology applications in the academic area especially for the preschools in Malaysia.

2. Measurement instrument for evaluating the practicality of the proposed requirement model: In the instrument, four qualities of acceptance involved are visualization, effectiveness, efficiency, fun and entertainment. These qualities are based on the extensive literature review and modified by experts to ensure the content validity of the items. The instrument is validated using reliability analysis on the basis of Cronbach's alpha (α) value for evaluating the proposed model. Then, the evaluation of ARMS prototype is used to measure whether AR technology is accepted in preschools as a support tool in Basic Science.

3. Theoretical framework related to AR adoption in teaching and learning Basic Science for preschool students: The purpose of theoretical framework in this study is to identify the relationship between three theories, namely Piaget's Cognitive Development Theory, Multimedia Learning Theory, and ELM. These theories are used to analyze the preschool characteristics associated with their cognitive development process.

4. Reusable virtual objects of muscular system: The objects that are generated for this study can be reused for other research. The advantages of reusing the ARMS objects are; the objects do not reproduce the same objects and help other researchers to save the development time.

1.10 Definition of Terminologies

This section describes the terminologies that are related to this study. The terminologies are as follows:

1. AR

   AR is a combination of the real world with the virtual environment. It adds virtual objects in the real environment. Users can see the virtual objects overlay in the real environment at the real-time without completely replacing the real world.

2. Augmented Reality for Learning Muscular System

   Augmented Reality for Learning Muscular System is a prototype to introduce the muscle system. It has been developed based on the requirement model. The targeted respondents are preschool students and teachers.

3. Muscular System

   The human body contains more than 650 individual muscles. The main function of this system is to allow the body to move and they are classified as skeletal, cardiac and smooth muscles. Each type has its own functions.

4. Preschool

   This study involves five preschools selected by the District Education Office of Kubang Pasu, Jitra, Kedah. These preschools are under the supervision of MoE. This study focuses on the Basic Science subject in the topic of human body.

1.11 Thesis Structure

This thesis comprises of seven chapters. The summaries of these chapters as follows:

Chapter 1 outlines the whole contents of this thesis. Chapter 1 entices the readers to understand the problems encountered during lessons about the topic that will be discussed. Thus, this chapter covers the problem statement, research questions, aim and subobjectives, scope, and the contributions of this study for the students themselves, teachers and community especially in education.

Chapter 2 provides literature review of related research; including implications of the study. The topics discussed are related to VR, types of VR, and the AR itself, which includes components, displays, issues, definitions and differences of AR and VR. In addition, this topic covers the cognitive development theory, theory of learning styles and learning theory. Moreover, this chapter also covers the Malaysian education, issues in Science subject, application of AR in education, application of AR in Malaysian education and Augmented Learning Environment (ALE).

Chapter 3 explains the methodology used in order to achieve the objectives of this study. This methodology is divided into five stages of processes, which are theoretical study, preliminary study, requirement model construction, Augmented Reality for Learning Muscular System construction, and evaluation of the proposed prototype. This chapter briefly describes the development process of Augmented Reality for Learning Muscular System including methods, data processing and instruments that have been used to conduct this study.

Chapter 4 discusses the results of data analyzed that are related to the current practice in teaching. The data are gathered using multiple fact finding techniques, which are interviews, observations and document reviews. The preliminary analysis involves five expert teachers in public preschools. The selected experts have been teaching the subject for more than ten years in public preschools. Based on the analysis made, it can be concluded that there are four elements that have been identified to develop the requirement model for this study, namely users, syllabus, learning environment, and hardware and software for elements of the Basic Science implementation module.

Chapter 5 presents the proposed requirement model for Augmented Reality for Learning Muscular System. The proposed model consists of three main components. The model is designed as a guideline to implement AR in teaching and learning science subject in the classroom.

Chapter 6 covers the results from the expert reviews and users. This chapter begins with describing the expert review for validation process and producing results. This chapter also presents the evaluation of Augmented Reality for Learning Muscular System prototype by experts and preschool students.

Chapter 7 summarizes all findings and discusses the limitation of this study. It also recommends the future research in the related area.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

A study on past research in related areas is necessary before proceeding to develop the Requirement Model of Augmented Reality for assisting learning in preschool education environment. This chapter covers the Virtual Reality (VR), Augmented Reality (AR), cognitive development theory, learning theory, learning style, Malaysian education, issues in Science subject, application of AR in education and Malaysian education, and Augmented Learning Environment (ALE).

2.2 Virtual Reality

This section discusses the VR background that includes the definition, history, and types of VR. VR is sometimes called Virtual Environments (VE) in the three-dimensional (3D) environment (Mazuryk & Gervautz, 1996; Olando, Pérez, Morillo, Fernández, & Casas, 2006; Troyer, Kleinermann, Pellens, & Bille, 2007). Brooks (1999) and Olando et al. (2006) described VR as a technology which allows users to immerse in VE and interact with the imaginary environment within effective way from VE's viewpoints. The VE allows the graphic display to look realistic (Grady, 2003).

The idea of VR has been introduced since 1965 over the past 40 years, when Ivan Sutherland designed the virtual display known as Head Mounted Display (HMD) technology for viewing 3D display of information (Cawood, & Fiala, 2008). This technology becomes ~~a~~ popular after 1980s. However, the term of 'Virtual Reality' was coined by Jaron Lanier, who is the founder of US-based VPL- Corporation (Li, Fengli, & Hong, 2010).

There are three different types of VR system (Costello, 1997; University of Calgary, 2004):

1. Desktop VR: The interaction between user and computer display is not well immersive in the VE.

2. Video Mapping VR: It is used with the camera to capture the user image. Then the image is transferred to a computer to generate the user as an avatar to immerse the user into full VE.

3. Immersive VR: This type fully replaces the real world with virtual world using the HMD special devices. This technology uses a powerful computer to smoothly render the actual VR application.

In the future, VR will change the traditional way to interact with the computer. This technology is still evolving in commercial and education domain. Therefore, it is possible to implement it in our daily lives. Nowadays, the VR has evolved into AR (Azuma, 1997; Kaufmann, 2003, 2005; Lyu, King, Wong, Yau, & Chan, 2005; Basogain, Izakar, & Borro, 2007; Pribeanu, Vilkonis, & Iordache, 2007).

2.3 Augmented Reality

The potential of AR technology will grow rapidly and it can be applied in engineering (Kumaran, Santhi, & Anand, 2007), medicine (Sielhorst, Obst, Burgkart, Riener, & Navab, 2004), construction (Webster, Feiner, MacIntyre, Massie, & Krueger, 1996) and education (Billinghurt, 2002).

Milgram, Takemura, Utsumi and Kishino (1994) have described AR as a subcategory of Mixed Reality (MR) in Reality-Virtuality (RV) continuum diagram. The concept is shown in Figure 2.1.

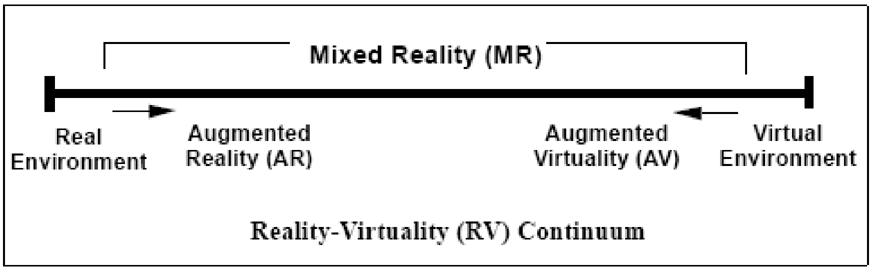


Figure 2.1: Reality-Virtuality Continuum (Milgram et al., 1994)

MR is a combination of Real Environment (RE) and VE (Mixed Reality Lab, NUS, 2003). The purpose of MR environment is to enhance the viewer's perception and to improve the interaction between user and real environment (Haller, 2004) by combining the real and virtual environment (Damala, Marchal, & Houlier, 2007). Furthermore, the addition of virtual objects into RE and VE would produce AR and AV respectively (Milgram, 1994). Thus, there are three characteristics of AR as provided by Azuma (1997), namely it combines real and virtual environment, it is interactive in real time, and is registered in 3D.

Ivan Sutherland is still considered as a pioneer of AR field since he first developed the display advancement in virtual area device, HMD in 1966. Researchers interested in this area noticed that it was the beginning of the innovative technology of AR (Azuma, Baillot, Behringer, Feiner, Julier, & MacIntyre, 2001). As evidence, several conferences focusing on AR technology have been held such as International Symposium on Mixed Reality and Designing AR Workshop (IEEE ISMAR), Designing Augmented Reality Environments (DARE) and International Workshop and Symposium on AR (ISAR). These conferences have made much impact to this area for enhancing and developing new AR technology in the future.

In the last few years, technological advancement in computer processing power as well as in computer vision research has helped to improve the study of AR. AR evolved from VR approaches (Azuma, 1997; Kaufmann, 2003, 2005; Lyu et al., 2005; Basogain et al., 2007; Pribeanu et al., 2007), thus allowing computer animation going one step further and opening up to new applications in many different fields (Tucker, 2004). The technology is still in its early stage however, the potential of AR technology grows rapidly and it can be applied in so many fields, not only in engineering (Kumaran et al., 2007), medicine (Sielhorst et al., 2004), and construction (Webster et al., 1996), but also in education (Billinghurt, 2002). The education sector ~~is~~ has also benefited from AR where it helps to create new exciting approach of delivering the teaching content. The textbooks are no longer ~~as~~ static view of text and graphics; the content can be viewed as a 3D in an open space.

Research in conceptualized AR in education through immersive virtual and real surrounding environment is considered as fast growth. Based on the previous studies, VR is shown to be able to raise interest on technology and motivate the students with the higher potential to enhance their experience in the learning environment. But, VR application technology is still being studied to generate the great challenges for developers and evaluators in this area. In medicine, VR is also known as motion sickness when the human brain is unable to differentiate between virtual and reality and causes nausea and heavy headache (Costello, 1997). AR solves this problem through superimposed virtual image in real environment through special marker where the human brain can still process and accept such idea.

Thus, AR is useful to enhance the users' perspective in the physical world beyond their experience. Some researchers (Azuma, 1997; Braz & Pereira, 2008; Kandikonda, 2011) describe AR as a combination of a real situation and virtual graphics in the same environment using special display devices. The next section discusses the basic components, display technology, and issues related to the AR.

2.3.1 Basic Components of AR System

A few researchers have discussed the basic components of AR. As suggested by Silva, Olivera, and Giraldi (2003), the three main components of AR are i) scene generator, ii) display technology, and iii) tracking system.

Azuma (1997) also named three components which are i) scene generator, ii) display technology, and iii) tracing and sensing. Baird (1999) suggested two main components, which are i) scene generator, and ii) display technology. Vallino (1998) mentioned two components as well, namely i) display technology, and ii) haptic technology. Bimber and Raskar (2006) proposed that the four main components of AR are i) rendering, ii) interaction devices techniques, iii) presentation and authoring, and iv) user interface. Table 2.1 summarizes the basic components of AR.

Table 2.1: The Basic Components of AR

Basic components	Description	Researchers
Scene generator	Device or software to generate rendering.	▪ Silva, Olivera, & Giraldi (2003)
	This component does not require a scene that consists completely of the computer graphic because the concept of AR is to enhance the real world with the virtual objects.	▪ Azuma (1997) ▪ Baird (1999)
Display technology	AR just adds the virtual object into the real environment and does not totally replace the real environment with VE.	▪ Azuma (1997)
	Requires a high resolution display technology likes HMD.	▪ Vallino (1998) ▪ Baird (1999) ▪ Silva et al. (2003)
	Depends on the situation. Spatial display configuration is much more efficient.	▪ Bimber & Raskar (2006)
Tracking and sensing	This is a strict requirement in AR. Specifically, AR demands tracker and sensor device when there are greater input variety and bandwidth, higher accuracy and longer range.	▪ Azuma (1997)
Tracking and registration	A fundamental challenge in AR development because it is so difficult to determine any movement in the fixed range area provided for 3D graphical objects to involve in coexist environment.	▪ Bimber & Raskar (2006)
Tracking system	The virtual objects in the virtual environment must be aligned with the real world.	▪ Silva et al. (2003)
Haptic technology	Provides the AR interactive environment with user interaction using the sensory device.	▪ Vallino (1998)
Rendering	Not all augmented reality applications require	▪ Bimber & Raskar

	real-time rendering.	(2006)
Interaction device techniques, presentation, and authoring	These components evolve from the combination of the existing areas such as VR, multimedia, or storytelling. But the module is not dominated in AR development.	▪ Bimber & Raskar (2006)
User interface	The application layer is the user interface that allows users to manipulate the application using the data glove, eye tracker or motion tracker.	▪ Bimber & Raskar (2006)
User	To measure the effectiveness of AR.	▪ Bimber & Raskar (2006)

Based on the review to implement AR, several aspects need to be considered. This study adopted Bimber and Raskar (2005) model to develop the requirement model. This model is required to accommodate the AR integration into this study. There are several modification models which have been developed based on their model. The next section discusses the display technology applied in AR environment.

2.3.2 Display Technology in AR

There are several comparisons between video and optical display technology that have been used in AR environment. Table 2.2 summarizes both the video and optical see-through. The table comprises of several aspects such as designing, technology, performance issue review from literature, which were highlighted below (Rolland, 1995; Piekarski, 2004).

Table 2.2: Comparison between Optical and Video See-Through Display

Feature	Optic	Video
Physical World Display	Transparent: Direct view to real-world through semitransparent mirror	Opaque: The small camera captures the real-world image but opaque fully blocks the other image for a moment until the opaqueness is removed to make the image visible again
System Latency	No latency to the real scene movement	Delay for actual movement
Resolution	High resolution	Low resolution
Field of View	Limited by internal optic and combiner	Limited separately by camera and displays
Peripheral Field of View	All activities are not captured by the device and to see the activities via side of device	Capture all activities by video camera
Perceptual	Perceive depth of nonoverlapping object	Perceive depth of overlapping object
Engineering and Cost	Include on and off axis design. The off-axis is expensive because it is difficult to design, more attractive and have a lot of prototypes developed for this type	The cost is based on functionality. The more powerful the HMD is, the more it costs.

HMD is a traditionally display technology in AR (Henrysson, Billinghurst, & Ollila, 2005). However, there are also other displays such as handheld (Wagner & Schmalstieg, 2006), spatial (Bimber & Raskar, 2005), PDA (Heng, Chen, Yang, & Sun, 2003), mobile phone (Henrysson et al., 2005) and web camera (Mohamad, Nazrita, Mohd, & Azlan, 2009; Desi & Dayang, 2010; Hafiza & Halimah, 2010).

This study applied the standard web camera as display hardware to capture and display the video. It is easier to use on any personal computer and the cost is low (Marchand & Chaumette, 2002; Mohamad et al., 2009) compared with other display hardware. The next section discusses the issues in AR.

2.3.3 Issues Related to AR Technology

In general, virtual and real environment are much difficult to combine into one environment at the same time. It needs to consider several aspects before developing the AR application. The challenge for a developer is to realize the movement of user eyes, head and glove position. Thus, the key issues discussed in AR development are the tracking system and registration system as factors that could lead to ineffective AR application and also affect the expected results in the evaluation phase (HitLabNZ, 2002; Kim, Lee, Park, Woo, & Lee, 2005; Nihra & Norazlina, 2007).

The purpose of tracking system is to ensure and establish the head position when movement activities and the orientation of the object in the real environment (Sinclair, 2004). However, Nihra and Norazlina (2007) pointed out that it was also important to provide the correct orientation when the user moved around; not only focused on fixed position. The display system is supposed to acquire the correct information with the combined real world and the virtual object to determine the position user in real time.

Apart from that, registration is the main problem in recognizing the correct location for appearing virtual objects and the actual environment in one display view at the same time coexist (Sinclair, 2004). It can give an impact when virtual object is displayed out of viewer range. Figure 2.2 summarizes this situation. The tracking system could be functioned to determine the real world position and orientation, while the graphic system draws the virtual object in the correct position and the display system combines both real and virtual to user viewer using a display device (Sinclair, 2004).

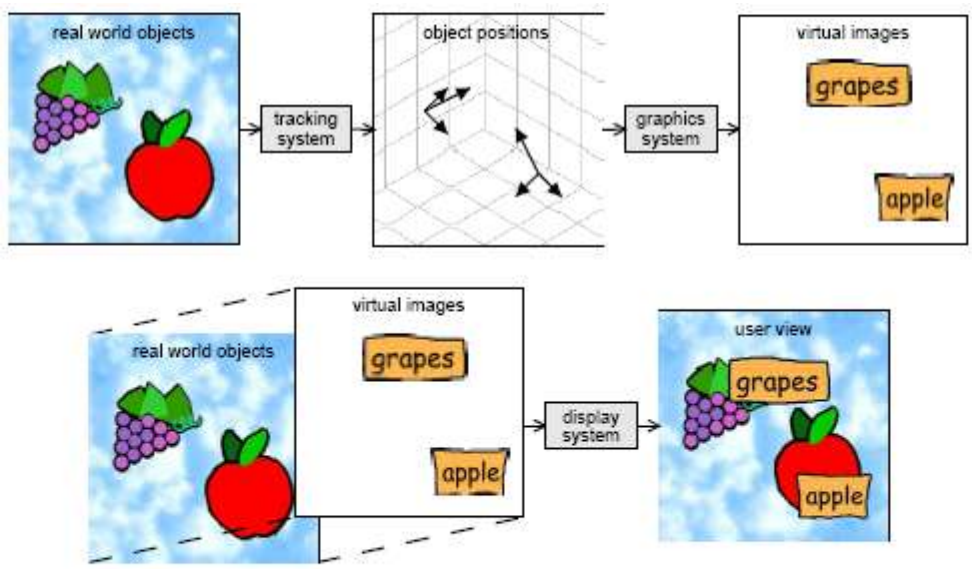


Figure 2.2: General Relation Tracking and Registration in AR Application (Adapted from Sinclair, 2004)

2.4 VR Versus AR

VR requires total immersion in the virtual world environment that replaces the real world (Grady, 2003). However, AR is augmenting the real world scene necessitating user perception through the addition of virtual objects (Vallino, 1998; 2002). The combination of virtual and real environment produces augmented display (Vallino, 2002). Thus, an AR is a combination of both real and virtual objects which coexist in the same space for user vision.

AR and VR are significantly different from several aspects. Based on the review from Costello (1997), Vallino (2002), Kaufmann (2003), and Nihra and Norazlina (2007), the differences in several aspects are explained in Table 2.3.

Table 2.3: Comparison between AR and VR

Differences	**AR**	**VR**
Environment	Combines both real and virtual objects coexist in the same space and in real-time at real environment.	VR requires total immersion in the virtual world environment that replaces the real world.
User View	Allows user to see the real world's surrounding and the virtual object.	Users only see the virtual environment.
Health Issues	AR solves the "motion sickness" problem through superimposed virtual image in real environment using special marker.	VR causes "motion sickness" where human brain is unable to differentiate between virtual and reality and causes nausea and heavy headache.
Safety	Users feel comfortable and able to control the environment.	Users feel unsafe because their views are blocked by the virtual environment.
Sense of immersion	None – low	Medium – high.

Based on the explanation of the differences between AR and VR, it can be concluded that AR is more suitable to be implemented in education. This is because AR does not distract the students from the real world, hence they are able to utilize the technology and at the same time receive instructions from teachers. Moreover, it is much safer to be used as a tool in teaching and learning compared to VR since AR solves the motion sickness issue raised by VR. The next section discusses the learning theories applied in this study.

2.5 Learning Theories

This section will discuss the three theories supporting this study. The theories consist of Cognitive Development by Piaget, Multimedia Learning Theory by Mayer, and Experiential Learning Model by Kolb. The following are the reasons why the three theories become dominant in this study:

1. Piaget's Theory: The cognitive development theory is applied to recognize the characteristics of the children in this study.

2. Multimedia Learning Theory: This study adopted the four principles to integrate and support the prototype of muscular system. The principles consist of coherence, spatial contiguity, multimedia, and voice.

3. Experiential Learning Model: This study applied the experiential as learning style to develop the students' skills based on thinking, feeling, doing, and watching process.

2.5.1 Piaget's Theory on Cognitive Development

Jean Piaget is an important person in cognitive development theory. The Piaget's concept of cognitive development is concerned about the general evolution in the nature stages of children to adapt themselves into the current environment (Beilin & Pufall, 1992). Piaget emphasized on the functions and response of the minds to the environment (Jas, 2000). Piaget realized the children have a sense of curiosity and actively respond to the environment by their understanding or cognitive abilities.

Based on Piaget's theory, there are four levels of child development. According to Jas (2000), each level has the perspective and the ability of certain children to solve problems and understand the environment. Table 2.4 displays the stages of cognitive development.

Table 2.4: Stages of Cognitive Development (Adapted from Atherton, 2009)

Stage	Characterized by
Sensory-motor (Birth – 2 years)	1. Differentiates self from objects. 2. Recognizes self as agent of action and begins to act intentionally: eg Pulls a string to set mobile in motion or shake a rattle to make a noise. 3. Achieves object permanence: realizes that things continue to exist even if it is no longer present to the sense. 4. Children use the senses such as attention, auditory and motor activities to explore the environment. 5. Movement depends on the spontaneous response.
Preoperational (2 – 7 years)	1. Learn to use language and to represent objects by images and words. 2. Thinking is still egocentric: has difficulty taking the viewpoint of others. 3. Classifies objects by a single feature: eg group together all the red blocks regardless of shape or the entire square block regardless of colour.
Concrete operational (7-11 years)	1. Able to think logically about object and events. 2. Achieves conservation of number (age 6), mass (age 7), and weight

		(age 9).
	3.	Classifies objects according to several features and can order them in series along a single dimension such as size.
Formal operation (11 year and up)	1.	Able to think logically about abstract propositions and test hypotheses systematically.
	2.	Becomes concerned with the hypothetical, the future, and ideological problems.

Piaget stated that the child's ability goes through a dramatic change from infancy to adolescence. He also recognized the environment factor in determining the child's ability. He realizes children as active, and should be encouraged to explore and should be exposed to a stimulus (Jas, 2000).

In addition, the children always love to explore new experiences to acquire new skills and knowledge through the senses. This experience can be obtained through a structured physical movement and organized, especially for preschool level (Zainun, 2006). According to Jas (2008), children at this age should be trained so that they can concentrate and build a more effective memory.

In relation to this study, this theory focuses on the young childrens' characteristics for the preoperational stage. According to Ismaiza (1999), this period is the exact time each pupil begins to learn new knowledge, enhance their skills to improve self-confidence and also for mental development such as memory, imaginations, thinking, perception, and intellectual reasons as a process of cognitive thinking. Consistent with Piaget's theory, this study emphasizes on the interaction with the objects, ideas, and communication to obtain information (Shahrani, 2004).

2.5.2 Multimedia Learning Theory

In general, learning theory is a theory that focuses on explanations on how learning occurred in the individual. Learning theory provides a basis for general strategies that can be used to improve the quality of learning.

Multimedia Learning Theory is developed by education psychologist, Richard E. Mayer. This theory involves multimedia presentation of explanation in verbs and visualization images as an approach in cognitive psychology of how humans learn from words and graphics (Moreno & Mayer, 2000; Mayer, 2001, 2005; Mayer & Moreno, 2006). According to Mayer (2009), multimedia learning refers to words and pictures.

Figure 2.3 illustrates the cognitive thinking of multimedia learning model to represent the human information-processing system. The boxes represent memory storage which is sensory memory, working memory, and long-term memory.

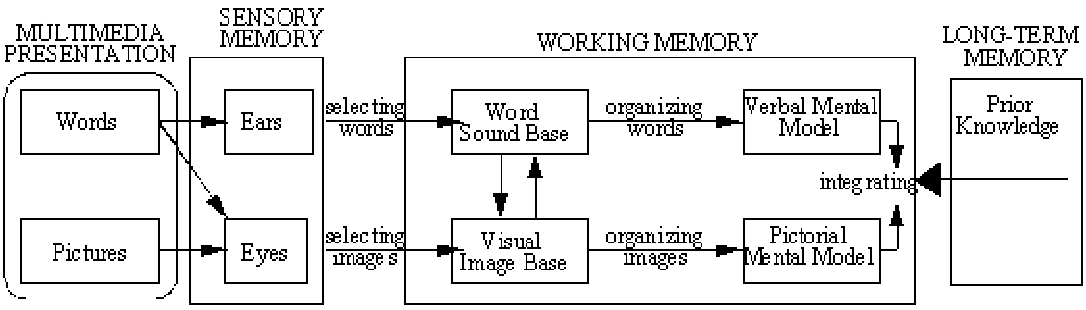


Figure 2.3: Cognitive Thinking of Multimedia Learning (Adopted from Moreno & Mayer, 2000)

Based on Figure 2.3, the arrow from words to ears and eyes are registered in sensory memory. The arrows from words to ears correspond to spoken text that has been registered in the ears, while the arrows from words to eyes correspond to printed text that has been registered in the eyes. It is the same with the pictures that registered in the eye sensory memory while looking at the pictures. According to Sun (2007), the sensory memory is the shortest memory typically 0.5 seconds until 4 seconds.

Next is the working memory box. Working memory is used for temporarily holding the data typically for 15 seconds until 30 seconds (Sun, 2007). There are two subboxes in this working memory. The left subbox represents data from the sensory memory box. On the other hand, it has represented the data constructed in the working memory. Mayer (2009) defined multimedia instruction as the material that has been presented in the verbal form; while picture is the material that has been presented in the pictorial form. The auditory or verbal are the sound images of word, while visual or pictorial model is visual images of pictures. Finally, long-term memory box has stored a large number of data within a long period of time.

There are 12 principles in cognitive multimedia learning consisting of coherence, signaling, redundancy, spatial contiguity, temporal contiguity, segmenting, pretraining, modality, multimedia, personalization, voice, and image (Mayer, 2009). The principles are divided into three categories of principles in multimedia learning which are:

1. To reduce extraneous process: This process provides the irrelevant information to make the confusion in the learning session. The extraneous processing overloads when a situation that demands the extraneous material in a learning session affects the cognitive capacity or presented in confusing ways. There are five principles in this category, which are (Mayer, 2009):

a. Coherence: People learn better when extraneous material is excluded rather than included.

b. Signalling: People learn better when cues that highlight the organization of the essential material are added.

c. Redundancy: People learn better from graphics, and narration compared with graphics, narration and printed text.

d. Spatial contiguity: People learn better when corresponding words and pictures are presented near than far from each other on the page or screen.

e. Temporal contiguity: People learn better when corresponding words and pictures are presented simultaneously rather than successively.

2. To manage the essential process: The essential processing is a cognitive processing that aim to represent the essential material in working memory. The essential process overloads when humans are inexperienced and the presentation is fast with the basic material. There are three principles in this category which are (Mayer, 2009):

   a. Segmenting: People learn better when a multimedia message is presented in user-paced segments rather than as a continuous unit.

b. Pretraining: People learn more deeply from a multimedia message when they know the names and characteristics of the main concepts.

c. Modality: People learn more deeply from pictures and spoken words than pictures and printed word.

3. To foster the generative process: The generative process provides sense making and organizing the material into coherent structures. It also integrates each of structures with the prior knowledge. There are four principles in this category (Mayer, 2009):

    a. Multimedia: People learn better from words and pictures than from word alone.

    b. Personalization: People learn better from multimedia presentations when words are in conversational style rather than in formal style.

    c. Voice: People learn better when the narration in multimedia lesson is spoken in a friendly human voice rather than a machine voice.

    d. Image: People do not necessarily learn better from a multimedia lesson when the speaker's image is added to the screen.

To relate this theory with this study, four principles are considered:

1. Coherence: The extraneous material such as irrelevant words, picture, sounds, music, unnecessary words and symbols are excluded from multimedia presentation.

2. Spatial contiguity: When words and picture are near on the page or screen, humans are able to handle them into working memory at the same time. Meanwhile, humans are less able to handle them into working memory at the same time. It makes them understand the information better when words and pictures are near each other.

3. Multimedia: Multimedia techniques involve words and pictures to construct and to build connection between verbal and visual mental models.

4. Voice: The voice technique uses the human voice to make the presentation more understandable rather than using a machine's voice.

2.5.3 Experiential Learning Model on Learning Style

The definition of learning style is the way to learn knowledge according to individual preference (Honey & Momford, 1992; MoE, 2001; Azizi, Yusof, Shahrin, & Wan, 2002; Rohaila, Norasmah, & Faridah, 2005). Thus, the main role of teachers is to motivate students to learn based on their strengths and interest, learning preference, and styles (Montemayor, Aplaten, Mendoza, & Perey, 2009).

According to Azizi et al. (2002), students learn in various ways such as reading, watching, talking, self-learning, group learning, learning in a relaxed, and learning through music. Thus, to make the teaching and learning sessions effective, teachers need to recognize their students learning style (Montemayor et al., 2009). Hence, Prashnig Style Solution (2001) identified the benefits of understanding the learning styles for students and teachers as shown in Table 2.10.

Table 2.5: The Benefits of Understanding Learning Style (Adopted From Prashnig Style Solution, 2001)

Category	**Benefit**
Students	Important self-knowledge gained
	Strengths and weaknesses in learning revealed
	Self-esteem improved
	Study skills enhanced
	Misunderstandings with teachers and parents prevented
Teachers	Accurate picture of classroom diversity
	Clear grasp of individual students' biological learning needs
	Reasons for underachievement exposed
	True needs of slow learners and 'gifted' students revealed
	Communication with students and parents improved
	Group work more successful
	Team spirit enhanced
	Student/teacher interaction improved
	Better time management
	Less stress - day-to-day and in one-off situations
	Better results and more job satisfaction

Based on the Kolb’s Learning Model, students will be excellent when their skill can be developed through four stages of learning cycle in two-dimension (Rohaila, Norasmah, & Faridah, 2005) as displayed in Figure 2.4.

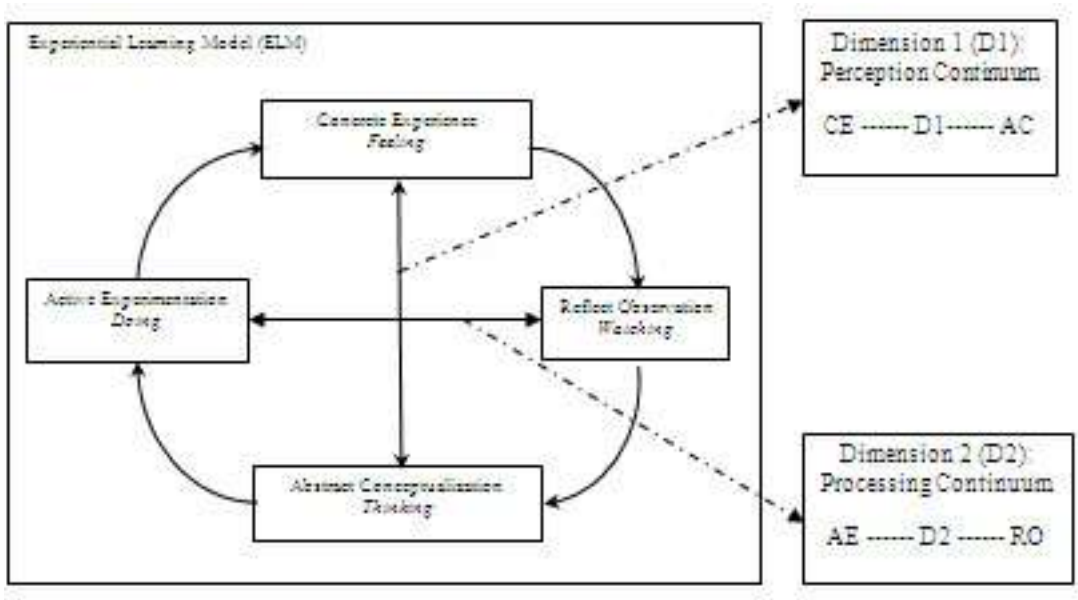


Figure 2.4: Experiential Learning Model (Kolb, 1984)

1. Perception Continuum: The first dimension on the vertical axis is a dimension to receive information in two ways that is the concrete experience of abstract or conceptual. This dimension refers to emotional response that is preferring to learn by thinking or feeling:

    a. Concrete Experience (feeling): Students acquire information by direct experience, specific experience and relating to people in community.

    b. Abstract Conceptualization (thinking): Students are able to understand the logical analysis of ideas and understand the situation.

2. Processing Continuum: The second dimension is the ability to process the information on the horizontal axis of reflective observation or active experimentation. This dimension mentions to approach the learning task

preferred by doing or watching. Students will process information either intentionally or reflection to do something that is active experimentation:

c. Reflect Observation (observing): Students make observation before making a judgement by viewing the environment from different perspectives.

d. Active Experimentation (doing): Students are able to achieve their aims by influencing people and events through action including risk-tasking.

Table 2.6 summarizes the activities involved in each stage in ELM.

Table 2.6: Activities in ELM

Dimensional	**Activities**	**Involvement**
Concrete Experience	Students participate fully in an active experience, open-minded and adaptable.	Feeling
Reflect Observation	Students become observers by using skills such as listening, observing and realizing the changes that occur within the new experience.	Watching
Abstract Conceptualization	Students should try to arrange and organize the information in a systematic and logic in the form of concepts, theories and ideas.	Thinking
Active Experimentation	Students directly involved with the environment to solve the problems.	Doing

2.6 Malaysian Education

There are two ministries handling education matters in Malaysia, namely the Ministry of Education (MoE) and the Ministry of Higher Education (MoHE). The responsibility of MoE involves the preschools, primary schools, secondary schools, and high level of education such as universities, colleges, and polytechnics are dealt by MoHE.

According the 10th Malaysia Plan (RMK10), Malaysia has made great strides in education internationally. Thus, in order to ensure students' achievement and improvement in line with other developed countries, Malaysia has taken part in the Programme for International Student Assessment (PISA). In addition, it still continues participation in the Trends in International Mathematics and Science Study (TIMSS). The purpose of joining the programme is to monitor students' performance in Science and Mathematics subjects which will be evaluated based on the assessment and international standards. The next section discussed the preschool syllabus.

2.6.1 Preschool Curriculum

Referring to the National Preschool Curriculum (MoE, 2001), there are six major components in the preschool curriculum which are implemented together based on the students' progress as follows:

1. Language and Communication: This component includes four languages which are i) Malay, ii) Chinese, iii) Tamil, and iv) English. Thus, these

components integrate the four bases of skills namely; i) listening, ii) speaking, iii) reading, and iv) writing.

2. Cognitive Development: This component involves the concepts of Basic Science and Mathematics. The aims of this component are to develop the cognitive skills and foster positive attitudes towards Science and Mathematics.

3. Spiritual and Moral: The spiritual component emphasizes on the knowledge, skills and basic practices that should be understood by Muslim children. Meanwhile, the moral component highlights the development of ethics in order to practice and appreciate the values inherited by multiracial societies.

4. Social Emotion Development: Matured emotional control and social skills. These skills are important for students to learn to control their emotions, thoughts and actions in accordance with the environment.

5. Physical Development: This component focuses on the development and physical growth from three important aspects, which are psychomotor, health and safety.

6. Creativity and Aesthetics: This component focuses on the creative development through imagination and thoughts through art activities. This component is important to help students build their confidence and a sense of desire and self-interest.

2.6.1.1 Composition Curriculum

Normally, there are seven factors that need to be considered during the teaching and learning session. The factors involved in the learning session are the basics of ICT skills, physical development, cognitive development, generic skills, social emotional development, personality, attitudes and values. However, based on the Level 1 curriculum four factors are highlighted, which are i) reading, ii) writing, iii) listening, and iv) arithmetic and reasoning. In addition, The Level 1 curriculum consists of three modules, namely i) Basic Core Module, ii) Theme Core Module, and iii) Elective Modules.

This study focused on the Themes Core Module especially in Literacy Science and Technology (LST). The purpose of LST is to build the students' creativity and innovation based on their experience in science itself. The LST is a combination of three elements consisted of i) science, ii) design, and iii) technology and ICT for Level 1.

Themes Core Module is divided into two categories which are i) Learning about Living Things and ii) Learning about the World around Us. However, this study focused on the Learning about Living Things. There are four main subtopics in this topic, namely i) human body, ii) animals, iii) plants, and iv) living things and nonliving things. Above all, this study highlighted the subtopic of Human Body. Table 2.7 shows the part on the human body:

Table 2.7: Subtopics of Human Body

Topic	Subtopic
Human Body	The names of different parts of the body
	The five senses and the part of the body linked with each sense
	Link good health with good habits
	There are different types of food
	Link eating good foods with good health
	We need food and water to stay alive
	We need to eat different kinds of food to be healthy
	We grow and change as we grow older

2.6.1.2 Content Standard and ICT Learning Standard

There are three qualities of learning consisting of i) values, ii) skills and iii) applications integrated with ICT as a support tool. Table 2.8 shows the combination effects of both Content Standard elements with the ICT Learning Standard.

Table 2.8: Mapping of the Content Elements and ICT Learning Standard

Elements	Description
Values	• Students use ICT in an accountable and ethical manner.
Skills	• Students select and apply appropriate ICT resource. • Students use ICT to seek, gather, process and utilize information. • Students use ICT to acquire and share knowledge.
Applications	• Students use ICT for solving problems and making decisions. • Students use ICT to enhance productivity and learning. • Students use ICT to express ideas and information creatively and innovatively.

Hence, the effectiveness and impact of ICT in the Science curriculum is important. In Science, ICT has opened up a whole range of potential as targeted by the MoE. In conclusion, the Basic Science emphasizes the use of ICT in teaching and learning session.

2.6.2 Issues in Science Subject

As mentioned in Chapter 1, in many cases, students feel that science is one of the most difficult subjects (Nani & Rohani, 2003) to learn and understand because some of the teachers are still using the learning technique which is outdated and they frequently use only one-way communication in teaching (Norjihan et al., 2006; Effandi & Zanaton, 2007). Most use teaching-centred approach and most of the time the teachers just feed the information to the students (Othman, 2010). This makes students not interested in science and felt that this subject is difficult to learn (Lilia, Mohamad, Subahan, Meerah, & Kamisah, 2006; Norjihan et al., 2006).

Furthermore, the report by the Human Capital Development of Transformation Programme in Science and Technology 2020 (Ruhaiza, 2012) showed the percentage of students studying in science stream have decreased to 29% in 2012 since 2007. Thus, this is consistent with the research in teaching science by Hasniza, Johari, and Yusof (2006), which found that:

1. Certain students sleep during the science class.
2. The class situation was uncontrolled.
3. Students did not understand even if they were assisted with the teaching materials because they used unsuitable materials.
4. Students lost focus.

5. Students were passive and were not active during the question and answer sessions.

Furthermore, based on the Schools Inspectorate Report 2009 (Othman, 2010), there are seven things that cause the quality of teaching and learning Science and Mathematics in the Primary School to be at a moderate level:

1. Teachers depend more on the contents available in textbooks or workbooks.
2. Teachers are not using a variety of teaching methods to attract the students' attention.
3. Teachers are less concerned with the combination of skills and knowledge.
4. Teachers provide less attention to the implement the moral values.
5. Teachers teach a lot of theories.
6. Teachers use less teaching material.
7. Teachers provide less attention to the fun-learning method.

Based on the interviews conducted with the Assistant District Education Officer Kubang Pasu (Mathematics & Science), Mr Shamsuri bin Othman on October 29, 2009, one of the weaknesses is some of the Science teachers are unprepared to teach the Science subject. They are not prepared with interesting teaching materials that can attract students' attention. They also do not fully understand what they are supposed to teach and how to make the knowledge meaningful and interesting. Thus, students feel that science is difficult subject to learn and understand (Kamariah, Mohamed, & Afendi, 2006). Moreover, another factor is the teachers who teach science instead of the science options (Lilia et al., 2006) have low level of confidence (Noor, 2000).

Computer aided learning has been proven as a good teaching material for the students in teaching and learning sessions (MDeC, 2007). Some of the examples such as animation of science activities allow the students to interact with animation and information presented on webpages or science-related application. The 3D animation is the latest innovation in education using multimedia application as learning aids. AR is one of the technologies that apply 3D and enhance the effectiveness and attractiveness in teaching and learning in the education domain (Ng, 2008).

Most of the current research in AR system focused more on higher education level subjects such as archeology (Balaguer, Lorés, Junyent, & Ferré, 2001), geometry and mathematics (Kaufmann & Papp, 2006), and human body operation (Juan et al., 2008). However, research in utilizing AR application as a tool for improving cognitive thinking at the children's level is still limited. Learning at this stage is very critical because this is where the cognitive development of a child starts (Saayah, 2009). Nonetheless, according to the previous study, researcher lacked requirement model as a guideline to develop the AR prototype for preschools in Malaysia. There is a need to utilize AR as a support tool for Basic Science subject.

2.6.3 Basic Science in Preschools

Science in early childhood education should start during the early schooling (Eshach & Fried, 2005; Trundle, 2009) to develop children's intellectual development (Lind, 1999; Saayah, 2009; Temiyasathit, Chomchid, & Promkatkeaw, 2009). Therefore, the scientific process including the observation, comparison, measurement, experimentation, exploration, communication, forecasting and applications are able to assist the intellectual development (Subahan, 1999; Nani & Rohani, 2003; Saayah, 2009).

Based on the previous studies, there are several advantages to teach science during the early childhood:

1. To increase students' interest in science (Nani & Rohani, 2003; Saayah, 2009).

2. To explore the nature based on the scientific thinking and reasoning (Lind, 1999; Eshach, & Fried, 2005).

3. To increase scientific vocabulary (Nani & Rohani, 2003; Tajularipin & Maria, 2004; Eshac & Fried, 2005).

4. To contribute in intellectual development (Subahan, 1999; Nani & Rohani, 2003).

5. To strengthen social and emotional development (MoE, 2001) is to enhance children's self-awareness, self-confidence, self-esteem, positive social interaction, and improve their interpersonal skills such as teamwork skills (Nani & Rohani, 2003).

In the preschool level, science education is seen as a way of thinking (Saayah, 2009) and to explore the world (Eshach & Fried, 2005) by themselves (Robiatul & Halimah, 2010). According to Subahan (1999), science learnt through self-activity is more effective because students can understand the facts, concepts, theories and able to solve problems. This is supported by Jas (2008) and suitable with the Piaget's theory, that students at this stage are able to think and conduct suitable activities.

According to Tajularipin (2004), the concept of Basic Science in early education should be in line with the level of ability and use the appropriate supportive tools to encourage students to be interested and participate in science lesson. Thus, combining the two approaches; i) the ICT and ii) the learning while playing also make the activities more fun because it is a natural desire for children (Robiatul & Halimah, 2010). In line with the development of child psychology, the learning process is easier to understand through the approach of play (Hashimah & Yahya, 2007).

In conclusion, the existing knowledge about the human body from formal and informal education is interesting topic to teaching and learning for pre-school students. However, the human body is one of the topics in the public preschool syllabus. Thus, the extra knowledge about the basis of internal organs in the human body should be added. This is important for the cognitive development to open their minds and attract them to learn about the internal organs, so they know how to maintain and protect the internal organs from injuries. In addition, this study used 3D animations. Previous studies have been proven that 3D animation in a Science subject helped the students understand more, learn and visualize the concepts better than conventional approaches, thus making the teaching and learning session more effective and attractive (Peter, Wahyudi, Thoe, & Hock, 2009; Robiatul & Halimah, 2010).

2.6.4 The Current Practice and Teaching in Basic Science Subject

Based on the literature study conducted, there are several methods applied by Science teachers in the teaching and learning sessions. Tajularipin and Maria (2004) suggested using creative essay, poems, songs, real model, mind maps, and tour in creating the existing learning environment. That is supported by the other researchers who said that creative essay is a powerful method to translate the students' understanding (McGinley, Pearson, & Spiro, 1989), exploring new ideas (Ammon & Ammon, 1987), looks at different perspectives for discussion (Tierney & McGinley, 1987) and able to remember certain information in long-term memory (Reaves, Flowers, & Jewell, 1993).

Based on interviews carried out over a period of two years with Basic Science teachers, there are several methods used to teach the Basic Science subject. The methods commonly used by the teachers were singing, drawing, picture charts, word cards, puzzles, exercises, worksheets, following the teacher movement and use of the Compact Disk (CD) as a technology approach. This study found that the main limitation of the methods in teaching and learning Science subject was mostly based on the books. Students just viewed the static graphics on the books without the effectiveness and attractive learning.

Additionally, the finding of a study by Zurina, Shamsudin, and Ahmad (2010) found that often, the use of technology in Science will assist teaching and learning sessions. Previous researches have proven that the use of technology creates a sense of excitement in science among students and assists the students' learning process with the fun, easy to understand, and encourage students to think critically and creatively (Lilia et al., 2006).

As mentioned in Chapter 1, most of the current researchers in AR focused more on the higher level of education. Thus, this study focused to implement AR in preschools. The technology used in this study is suitable to be implemented with the preschool students because their curiosity and imagination level is higher at this age (Saayah, 2009). The preschool students are familiar with individual bodies with the formal and informal lessons. However, there are not exposed to the basics of internal organs. Apart from that, this technology can help to build their creative thinking, improve their understanding and feel that science generally and muscular systems specifically are interesting topics to learn. The next section discusses the AR technology applied in education.

2.7 AR Technology Application in Education

AR is an innovative area of computer graphic advancement. The academic area is also affected by this technology and could be implemented in many areas of education such as medical (Sielhorst et al., 2004), geometry and mathematics (Kaufmann & Papp, 2006), archeology (Balaguer et al., 2001), and symbol languages (Wagner & Barakonyi, 2003).

AR technology is also an innovative tool to assist teachers in enhancing the quality of teaching. In this century, the education domain should shift from the traditional method of teaching to the new technology-supported materials or tools to improve the efficiency of teaching method (Balog et al., 2007; Basogain et al., 2007). This notion is strongly supported by the fact that nowadays students were born as digital natives which mean that they are growing up with technology (Martin et al., 2009).

2.7.1 Application of AR in Education

Many researches on the application of AR in the education domain have been conducted in the past. Based on the literature review, Table 2.9 displays the application of AR in different subjects such as astronomy, biology, storytelling, art, and surgery.

Table 2.9: AR Application in Education

Researchers	Subject	Description
Billinghurst, Kato, & Poupyrev (2001)	Storytelling	The study developed an AR application named MagicBook. This particular application materializes the content of the storybook's page via the AR virtual object. The virtual object is called avatar character in the scope of the study.
Shelton & Hedley (2002)	Astronomy	The study developed an AR application on solar system dedicatedly on sun and earth. The application possesses the ability to view the solar system from the students' view and position.
Fjeld & Voegtli (2002)	Arts	The study developed an AR application emphasizing on the manipulation of arts elements. The application is called Augmented Chemistry (AC). It allows the use of hand gestures to control and mould the elements of

		abstracts arts in chemistry atoms.
Shuhaiber (2004)	Surgery	The study developed an AR application on neurosurgery, otolaryngology and maxillofacial surgery. This application assists in enhancing the process of surgery on the aforementioned surgical categories.
Chien-Hsu, Chun, Po-Yen, & Fong-Gong (2007)	Chinese Language	This study developed an AR application to learn Chinese alphabets focusing for preschool students. The result revealed that this system made children easy to understand the pronunciations and memorize the Chinese alphabets. In addition, this study had shown the positive results in writing, reading, and memorizing the alphabets using AR by experimental groups.
Min-Chai & Jiann-Shu (2008)	English Language	This study developed an AR system to help preschool students to learn English. The system is known as Augmented Reality English Learning System (ARELS). This study integrated multimedia elements and users were able to control the English marker.
Juan et al. (2008)	Biology	The study developed an AR application on human's anatomy. The application focused on exploring internal human organs which were divided into male and female categories.
Min-Chai & Hao-Chiang (2010)	English Language	The study developed an AR application on the English Vocabulary. The application was named AREVLS and developed for primary schools. This study showed the students were able to interact with the virtual objects, thus improving their learning in interesting ways.
Pérez-López et al. (2010)	Science	The study developed an AR application on digestive and circulatory system for private primary schools in Spanish. The application was named HUMANAR. This study showed an application that was developed in a collaborative way to improve the understanding and positive attitude in teaching and learning sessions

of the proposed topics.

2.7.2 Application of AR in Malaysia Public School

The implementation of AR in Malaysia public schools is countable and scarce. This is true for both primary and secondary schools. The following section is dedicated to explicate the few studies conducted on the application of AR in primary and secondary schools.

Though few, there were studies conducted on the implementation of AR in primary schools. Norziha, Halimah, and Azlina (2010) developed the Augmented Reality Book Science in Deaf (AR-SiD) for the deaf students. The concept of this AR-SiD is AR-Book. AR-SiD contains 3D objects using markers and provides the symbol language. In addition, Hafiza and Halimah (2010) focused on the Malay Language for assisting rehabilitating students to learn how to read Malay Language during the activities of storytelling and reading conducted using AR technology.

There were studies conducted on the implementation of AR in secondary schools. Sin and Halimah (2010) developed Live Solar System (LSS) to help students in learning astronomy. It focused on Form Four students. LSS allowed students to explore the solar system to enhance their understanding. Desi and Dayang (2010) has developed AR prototype based on the Physic textbook. This study focused on the heat absorption and radiation experiments.

2.7.3 Advantages of Applying AR in Education

Many researchers (Bruce, 1997; Cooperstock, 2001; Billinghurst, 2002; Kaufmann & Papp, 2006; Kondo, 2006; Balog et al., 2007; Basogain et al., 2007; Juan et al., 2008; Martin et al., 2009) support that implementing AR in the education domain improves and empowers education by nurturing fun and attractive elements in learning among students. According to a previous study by Jong & Joolingen (1998), the learning process that uses simulations and computers will improve the students' understanding on the theoretical knowledge. It is supported by Kaufmann et al. (2009) and Martin et al. (2009) who said that using technology in the learning process has helped students to understand the difficult subject. There are several advantages in implementing AR in the education domain:

1. According to Billinghurst (2002), the reasons to implement AR in the education domain include the ability of AR to support seamless interaction, the use of tangible interface metaphor and transitional interface. The seamless interaction relates to the way of interaction where the students are populated in a group and situated at the same location viewing the virtual objects in the real environment. As for the tangible interface metaphor, it permits the manipulation of the virtual objects via dedicated AR devices such as HMD and joysticks. Last but not least, the transitional interface of AR allows the students to experience the joy of both worlds which are physical, referring to the real environment and virtual environment.

2. According Kaufmann (2003), AR is a powerful technology to be implemented in the education domain. This is due to the collaborative nature

of AR that permits the use of single virtual environment by multiple students in a real environment. In addition, he also states that from a psychological perspective, AR is safer to be used by the students since it does not immerse them completely in the virtual environment giving them the sense of comfort in learning.

3. AR can also contribute in enhancing the learning experience of the students. This is proven by Balog et al. (2007) who presented the finding of their study on AR in education domain. The study showed that AR attracts, stimulates, and excites students in learning new knowledge.

4. Looking from the teachers' point of view, AR technology improves the teaching skill by providing a platform for them to channel creativity in manipulating pedagogical tools. The effort of teachers in using AR in the pedagogical tools would influence the intellect of young students especially in preschools.

Based on the previous studies conducted on the application of AR in the education domain, it is clear that AR has paramount contribution in proliferating the quality of education. The similarities of the previous studies served as the supportive pillars of the study conducted to justify the need to implement AR in preschools. Additionally, the geographical scope of Malaysia in some of the previous studies helps in painting the overall picture and phenomena of AR in this country, which is paralleled with the geographical scope of the study, namely Malaysia.

2.8 Augmented Learning Environment (ALE)

The AR technology is potentially increasing for advancing the current learning environment. This technology is suitable for implementation in various fields of education discipline such as a simulation and training. Hence, ALE recommends AR learning environment which consists of some minimum devices in the classrooms such as laptop, video camera, LCD, and related devices to produce the environment (Whalley, Welch, & Williamson, 2006).

This study proposed that the requirement model and prototypes for supporting teaching and learning based on the ALE for the preschool level specifically in Basic Science subject. It considered three aspects, namely (i) technological tools, (ii) the safety aspect for the users, and (iii) the minimum costs to implement AR as a support tool in preschool environment.

2.9 Conclusion

AR is a potential technology to be applied in the education domain. Many reseaches conducted showed the potential of AR in the learning environment. The topic of human anatomy that covers the external body is too common and the students only learn the basic functions of the body. Therefore, this study aims to improve the existing knowledge by adding the basic knowledge of the internal organs and the students also learn the basic functions of the organs. Thus, from the literature, this study should be designed and developed by considering the several issues, which are components of AR, learning theory, and the preschool curriculum.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

Research methodology is a set of rules or methods used to conduct research within any discipline area (Noraina, 2005) with a systematic way to solve the research problem (Kothari, 2008). This chapter covers the research where the prototype will be developed as a proof of concept based on the constructed requirement model. There are five main steps in the methodology as shown in Table 3.1 and are explained further in the following sections.

Table 3.1: Research Phases

Phases	Activities	Techniques	Outcomes
Theoretical Study	• Investigate the implementation issues related to Basic Science subject in preschools. • Investigate the current practice to teaching Basic Science in preschools. • Identify hardware and software to implement AR in the preschool environment. • Study the theories of learning, cognitive,	• Literature review • Comparative study	• Issues related to AR in Basic Science. • Issues related to the current practice in Basic Science teaching and learning sessions. • List of hardware and software to implement AR in preschools. • Theories used in this study consist of Piaget's Theory, Multimedia Learning Theory, and Experiential Learning Model (ELM).

	and learning style. • Analyze and compare the AR model to determine the main components in requirement model of Augmented Reality for Learning Muscular System		• List of AR component in requirement model
Preliminary Study	• Analyze preliminary data related to the implementation of Basic Science subject in preschools. • Identify components to construct the requirement model of Augmented Reality for Learning Muscular System	• Multiple facts finding: • Interview • Observation • Documents review	• Components of Augmented Reality for Learning Muscular System
Requirement Model Construction	• Construct requirement model of Augmented Reality for Learning Muscular System • Review and validating the requirement model of Augmented Reality for Learning Muscular System using expert review	• Theoretical study • Multiple facts finding • Interview • Observation • Documents review • Expert review	• Requirement Model of Augmented Reality for Learning Muscular System • Validated Model of Augmented Reality for Learning Muscular System
ARMS Development	• Develop the Augmented Reality for Learning Muscular	• Prototype	• Proposed the Augmented Reality for Learning Muscular

	System prototype		System prototype

Evaluation	• Test the prototype model using experimental approach
	• Analyze the results by the:
	  • Experts
	  • Respondents
		• Questionnaire
		• Unstructured interview
		• Experimental design
		• Expert evaluation
			• Results of the quality criteria:
			  • Visualization
			  • Effectiveness
			  • Efficiency
			  • Entertaining and fun
			  • ELM

3.2 Theoretical Study

This phase reviews the conceptual ideas from the previous work discussed in Chapter 2. The information was gathered through extensive literature review and comparative study. Extensive literature in this study focuses on the collection of information regarding the concepts of existing AR, issues in AR, analyzing and comparing the AR model to determine the main components of the model Augmented Reality for Learning Muscular System, issues in learning science, issues in teaching and learning approaches for Basic Science subject, factors and criteria that influence AR in education, and theories that have some implications in this study. Thus, the outcome of this study will be used to justify the problem and issues related to the learning of Basic Science subject, and to construct research questions, objectives, and scope as discussed in Chapter 1.

3.3 Preliminary Study

This phase focuses on understanding the issues in learning science, the need of AR adoption in solving the identified problems, current practice of AR implementation in education and identification of necessary components to construct the requirement model of AR in Basic Science subject. The main objectives are to find out the specific target respondents for Augmented Reality for Learning Muscular System and their preferences in learning, either using conventional way or AR technology.

In detail, this study focuses on the internal organs known as muscular system. The topic was suggested by the expert teachers because the internal organs are difficult to visualize with the limited support tools.

Figure 3.1 shows the research procedure that has been followed in collecting data from selected Malaysian public preschools.

Get approval from the District Eduction Office Kubang Pasu

(Refer Appendix A)

↓

Make an appointment and meeting with Preschool Officer (Mdm Osma bt. Shafie) to obtain the names of preschool teachers who have served more than 10 years teaching Basic Science.

↓

Make an appointment and meeting with the headmaster at each school involved to obtain permission to use preschool teachers and students.

↓

Make an appointment and meeting with preschool teachers who were involved in this study.

Figure 3.1: Research Procedure

There were four teachers as expert respondents involved from four preschools respectively in Kubang Pasu, Jitra, Kedah (Refer Appendix B). In detail, this study has selected the expert respondents based on the teaching experience in early education for more than ten years in public preschools. The expert teachers were selected by the Kubang Pasu District Education Office.

There are two major approaches to gather related information which are i) secondary and ii) primary sources (Kumar, 2005). The primary source was acquired through interview and observation. On the other hand, the secondary source was based on document reviews. The information was focused on the issues in using technology as supportive tools, criteria to develop the objects, teaching approaches, and topic should be focused. Thus, the methods were discussed in the following subsections.

3.3.1 Data Collection Methods

Three multiple fact finding methods were used for i) interview, ii) observation, and iii) documentation review. The respondents for this study were the teachers with more than ten years of experience in Basic Science subject for preschool level. The data have been analyzed in this chapter as a summary to develop the requirement model for Augmented Reality for Learning Muscular System.

3.3.1.1 Interview

Interviews were very useful for information gathering at the beginning of the study (Zhang & Wildemuth, 2009). The goal of these interviews were to understand the Basic Science itself, to know the respondents' experience in using technology as a support tool in lessons, identify the characteristics of the objects that can attract the students' attention and get the general perspective of teachers, whether the muscular system is suitable to introduce for preschool students or not.

The interviews conducted in this study were open-ended and were conducted in four National Schools in the district of Kubang Pasu, Kedah. The following is the list of schools and teachers given by the Assistant District Education Officer (Preschool Officer), Kubang Pasu District Education Office, Mdm Osma binti Shafie:

1. Respondent 1: Sekolah Kebangsaan Binjal
2. Respondent 2: Sekolah Kebangsaan Guar Napai
3. Respondent 3: Sekolah Kebangsaan Wan Kemara
4. Respondent 4: Sekolah Kebangsaan Batu 8

This study applied open-ended interviews to identify the elements of implementing Basic Science subject in the preschools. The interviews were very useful for gathering information at the beginning of the study (Zhang & Wildemuth, 2009). The results of the interview are discussed in Section 4.2.1.

The first part of the interview contained the following questions related to the respondents’ experience in childhood education and usage of technology as a support tool in teaching:

1. How long have you been in early childhood education?
2. What are the children characteristics?

The questions were to ensure that respondents have experience in early education. Therefore, their views and opinion could be considered as valid and relevant to this study. The following section is the interview questions related to the Basic Science subject:

1. What is the concept in early education?
2. What is the concept in Basic Science subject?
3. What are the criteria for children at this age?

The next questions focused on the teaching approaches and characteristics of the objects that attract the preschool students. The questions were:

1. What are the teaching approaches used in human body topic?
2. Are there any themes used to teach the human body topic?
3. Do you think anatomy is suitable to be taught at this age?
4. What are the characteristics of the objects which should be focused on to attract the students?

The following questions focused on the AR technology and criteria commonly used as the support tools in Basic Science subject. The related questions were:

1. Generally, what is the problem using technology as a learning tool in Basic Science subject?
2. What are the advantages of using technology as a learning tool in Basic Science subject?
3. Do you know about AR technology?

4. Do you think AR could be a support tool in teaching and learning session?
5. Why did you not teach anatomy to students before?

3.3.1.2 Observation

This study used the nonparticipant involvement technique (Kumar, 2005) in performing the observations. The purpose was to study the practicality of the AR implementation in preschools. The researchers observed the class environments from three perspectives: position of students, learning space and layout of Information and Communication Technology (ICT) equipment. After performing the observation, details of the Basic Science matter was gathered using document review technique. The detailed discussion is in Section 4.2.2.

3.3.1.3 Document Review

The document review technique complimented the information gathered from the primary sources (Kumar, 2005). The documents were reviewed to determine the criteria and as a guideline based on the preschool curriculum. It involved three documents which are i) The National Preschool Curriculum (MoE, 2001), ii) The Lesson Plan Preschool Documentation, and iii) The National Preschool Standard Curriculum (MoE, 2011). The outcomes from this document review were used to develop the Basic Science subject component which was then being integrated into the requirement model of Augmented Reality for Learning Muscular System. The detail discussion is in section 4.2.3.

After identifying the Basic Science component, the next step was to construct the requirement model of Augmented Reality for Learning Muscular System.

3.4 Requirement Model Construction

This section discusses the elements which identified the findings obtained in the theoretical and preliminary study. The elements were reviewed and verified by using experts review approach consisting of expert teachers (refer Appendix C), and AR experts (refer Appendix D). This phase began with identifying the main components in the requirement. There were four steps involved:

1. Identify the elements in Basic Science subject.
2. Identify the elements in AR technology.
3. Identify and clarify the prototype processes.
4. Identify the related theory for effective AR implementation in Basic Science subject.

Thus, the findings and discussion of the proposed requirement model are discussed in Chapter 5.

3.4.1 Review and Validation of the Requirement Model of ARMS

The requirement model of Augmented Reality for Learning Muscular System was reviewed and validated by two domain experts in Basic Science and AR. Four Basic Science teachers and two experts in AR were selected. The selected experts in this study required strong background experience in the related area. The Basic Science experts were Basic Science subject teachers. On the other hand, the AR experts were researchers at the Human Interface Technology Laboratory New Zealand (HITLabNZ), University of Canterbury, New Zealand, and AR Lecturer, Universiti Utara Malaysia (UUM). They are well-known in the AR research and industries.

The procedures for the expert review were arranged using the following manner:

1. Setting up the review based on the selected evaluation attributes
2. Conducting the review through face-to-face and email
3. Prepare and analyze the results of each review

The results are discussed further in section 6.2.

3.5 Augmented Reality for Learning Muscular System Development

Generally, prototyping is a widely used approach in multimedia development (Barry & Lang, 2001). According to Jamalludin, Baharuddin, and Zaidatun (2003), prototype is a system that is almost similar to the actual software. In this study, the prototype was constructed based on the proposed requirement model verified by the respective experts. The development of the Augmented Reality for Learning Muscular System prototype applied multimedia approach consisting of three activities which are i) preproduction, ii) production, and iii) postproduction (Barry & Lang, 2001; Zettl, 2001) as below:

1. Preproduction: This phase involved creating the content outline of storyboard, namely marker, comprehensive notes, and 3D objects. In

addition, this activity was also to create the content in comprehensive notes and exercise.

2. Production: This phase involved the development of interface, graphics, 3D objects, and 3D animation.

3. Postproduction: This phase involved the evaluation process.

In addition, the documentation is also provided in this study. Documentation is an important feature of high-end multimedia titles (Nathan, 2004). Detailed descriptions of these activities are in Section 5.3.2.1. The next section discusses the evaluation.

3.6 Evaluation of the Proposed Prototype

This study was designed to examine the potential of the ARMS prototype in improving the cognitive thinking of students in learning the muscular system. The methods used in this study were experimental approach, questionnaire survey, and unstructured interview.

3.6.1 Population and Respondents

The evaluation was carried out at four different government preschools in Kubang Pasu, Kedah. This study involved four expert teachers in early education. In total, 88 students participated in this study. The students' age ranged from five to six years old.

3.6.2 Research Instruments for This Study

Instruments utilized were developed for the following phases:

1. Review and validation requirement model for expert teachers (refer Appendix C)
2. Review and validation requirement model for AR experts (refer Appendix D)
3. Questionnaire for expert teachers (refer Appendix E)
4. Unstructured interview for preschool students (refer Appendix F)

3.6.2.1 Instruments for Expert Teacher and Expert AR

The main objective is to gain comments and suggestions for improvement of the proposed model of Augmented Reality for Learning Muscular System from expert teachers and AR experts. It was also to ensure that the proposed model represented the systematic and clear approach for the development of Augmented Reality for Learning Muscular System. The instruments were developed to get the initial feedback based on the following components and elements:

1. Expert teachers

    a. Elements in teaching & learning Basic Science subject: The elements need to be considered for effective implementation of AR application as a support tool for Basic Science subject. The elements involved the users, syllabus, learning environment, and software.

b. Experiential Learning Environment (ELM): The purpose of ELM in this study to recognize the students' skills based on their thinking, learning, feelings, doing, and watching process.

2. AR Experts

   a. Components of Requirement Model for ARMS: The elements were designed to ensure the element of AR support in the teaching and learning in the classroom environment for Basic Science subject.

   b. Elements of AR: The purpose is to ensure that the elements are sufficient to develop AR objects to introduce the muscular system topic for preschool children.

3.6.2.2 Questionnaire

The research instrument represents the data collection method, which is the questionnaire (refer Appendix E) in this study. The questionnaire was attached with a cover letter explaining the purpose of this research. The questionnaire involved teachers and students. The questionnaire consisted of six sections. The first section had two parts; the first part focused on the general information of the respondents including name, school address, telephone number, email, total students in class and summary of the ARMS. The second part was to list down the usual learning aids to teach Basic Science.

Section two to six used Likert-scale to measure the level of agreement or disagreement to a statement. There were five, seven, or ten-point level format (Dawes, 2008). However, this study recommended the application of a 5-point scale to produce responses and decrease the relative mean score compared to using the 10-point (Dawes, 2008). The Likert response is level 1 for strongly disagree, level 2 for disagree, level 3 for neither disagree nor agree, level 4 for agree, and level 5 for strongly agree are shown in Figure 3.2.

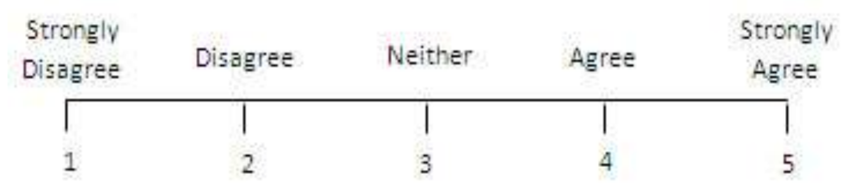


Figure 3.2: The Level of Likert-Scale

Therefore, this study needs to convert the Likert-scale as interval scale to analyze the data effectively (Brown, 2011) as shown in Table 3.2. The results were analyzed using statistical methods, which include mean and standard deviation.

Table 3.2: The Level of Interval Scale

Level	**Description**
1.00 – 1.99	Strongly disagree
2.00 – 2.99	Disagree
3.00 – 3.99	Neither
4.00 – 4.99	Agree
5.00 – 5.99	Strongly agree

The five items were constructed based on the extensive review of the literature to attribute of visualization (13 items), effectiveness (13 items), efficiency (3 items), entertainment and fun (9 items), and ELM (13 items). The questionnaire items and references are shown in Table 3.3.

Table 3.3: Questionnaire Items and References

Attribute	**Question Items**	**Items**	**References**
Visualization	12	• Display text and graphics provided are easily understood • Size markers provided are appropriate and easily detected • Provide appropriate information for preschools • The comprehensive note content is easily understood. • Layout content is clear • Use suitable graphics to attract childrens' attention • Text and graphics affect the learning system • Use suitable font sizes for comprehensive notes • The text colour is easy to read	Zahari, 2009
		• 3D objects in this video are clear and easy to understand in accordance with the information. • 3D model is able to provide additional information to students. • The quality of video is good	VR Questionnaire, nd

Effectiveness	13	• The AR technology assists by making me more effective in the teaching and learning process • AR technology makes me more interested in the teaching and learning process • AR technology is very useful • AR technology is easy to use • AR technology is flexible • I learn to use it quickly • I easily remember how to use this AR technology • I would recommend this application to friends • It is fun to use • I am satisfied with it	Lund, 2001
		• I would use this application again as a support tool in lessons • The support tool such as this is able to attract the students' attention than with the usual support tools • This technology is being introduced to the preschool students	Evans, 2009
Efficiency	3	• Teaching method is suitable for use in other subjects • Content of this topic can be used in different learning situations (eg self-learning or collaborative) • Content of this topic is suitable for a wide variety of situation, time and place (eg at school, at home, at cybcercafe)	Zahari, 2009

Entertaining and fun	9	• ARMS attracts and captures my attention • ARMS arouses my teaching or learning emotion through AR technology • ARMS presents the information in interesting ways • The use of ARMS is entertaining for the students to help them understand the information delivered • ARMS makes my students laugh • I was happy to use ARMS as my support tool • I was excited when teaching or learning with ARMS • Teaching or learning using ARMS is enjoyable • I feel comfortable to teach or learn with ARMS	Ariffin, 2009

ELM	13	• Understanding the concept and the principal • Students try to organize and arrange information logically • Students try to organize and arrange systematically information in the form of the concept • Students try to organize and arrange systematically information in the form of the theory • Students try to organize and arrange systematically information in the form of the idea • Students participate fully in new experiences actively • Students participate fully in new experiences with an open mind • Students acquire information by direct experience • Students are directly involved in the environment in finding solutions for problems (experimental) • Students are able to complete the exercise provided • Students become observers using listening skills in a new experience • Students become observers to observe skills in new experience • Students become observers with an awareness of changes in skills in the new experience	Rohaila, Norasmah, & Faridah, 2005

The questionnaire was conducted after the experimental group method. After the experiment, teachers were asked to fill out a questionnaire to ensure that ARMS was able to assist teaching and learning in human body topic.

3.6.2.3 Unstructured Interview

This study conducted the unstructured interview (refer Appendix F) for preschool students. This is because to get information directly from students was quite difficult. Several of them were not able to read and understand the meaning of the sentences. In unstructured interviews, 10 open-ended questions were asked orally to draw out familiarity, visualization, effectiveness, entertain, and fun related to the prototype. The results of the unstructured interview were discussed in Section 6.3.2.

3.6.3 Pilot Test

Therefore, a pilot survey was conducted before the actual set of questionnaires was distributed to 20 pretest respondents from the population of interest. Specific purposes of reliability tests were as follows:

1. To identify the problems of understanding and interpretation of the questionnaire items
2. To obtain feedback from the respondents to improve the questionnaire items
3. To estimate the time required to answer the questionnaire items
4. To identify the redundant questionnaire items
5. To determine whether the prototype meets user reliability requirements
6. To determine prototype reliability

In addition, this stage is important to measure the reliability of each item in the questionnaires. The data obtained from this pilot study has been analyzed and repaired. The questionnaire in this study is to measure the quality of acceptance involved the visualization, effectiveness, and efficiency as indicators.

3.6.4 Experimental Design

An experimental design is the traditional approach to conduct quantitative research (Creswell, 2002). This study used the Within-Group type which was repeated measures experiments as an experimental design (Creswell, 2008). The researcher compared the groups under one experimental conduct with its performance under another conduct. Figure 3.3 illustrates the steps in the repeated measure experiment design.

Time →					
Select Participant for Group	Measure or Observation	Experimental Treatment #1	Measure or Observation	Experimental Treatment #2	Measure or Observation

Figure 3.3: The Repeated Measures Design (Adapted from Creswell, 200)

During experimental session, two sessions were conducted on the days which involved the control group and experimental group. It consisted of three main stages as shown in Table 3.3.

Table 3.4: Experimental Process

Stage	**Description**
Preparation	1. Prepared ARMS comprehensive notes (refer Appendix G), ARMS marker (refer Appendix H), ARMS exercises (refer Appendix I) and ARMS user manual (refer Appendix J) for teachers. 2. Prepared ARMS comprehensive notes, ARMS marker and ARMS exercises for students. 3. Selecting the students and dividing them into groups. Minimum 5 students per group. 4. Prepared 3 laptops for the demonstration.

	5.	Prepared the Questionnaire Form for teachers and students.
Execution	1.	Distributed ARMS comprehensive notes, ARMS marker and ARMS exercises to their teachers.
	2.	The teachers conducted the class manually (control group) to teach the muscular system.
	3.	The experimental group was conducted after the control group session.
	4.	Conducting the experiment by giving the ARMS marker to each group.
	5.	Teachers demonstrated the ARMS prototype and then students tried themselves.
	6.	Teacher distributed the ARMS exercises to students.
	7.	Students who have completed the exercise were required to check the result using ARMS prototype.
	8.	Distributed the Questionnaire Form for teachers with the several procedures: a. Explained to respondents the purpose of study. b. Provided clear instruction as how to answer the questions. c. Gave participants enough time to complete the questionnaire form. d. Check if respondents missed any the data in the questionnaire form. e. Conducted the unstructured interview with the students
Refinement	1.	Collected Questionnaire Form from the teachers.
	2.	Analyze the data using SPSS.

3.7 Conclusion

This chapter described the processes involved in this study to achieve all objectives in Chapter 1. It also discussed the research process in developing the Augmented Reality for Learning Muscular System and the method used in this study. This study consisted of five phases in the methodology including a theoretical study, preliminary study, requirement model construction, Augmented Reality for Learning Muscular System development and evaluation. The next chapter will propose the requirement model for Augmented Reality for Learning Muscular System in Basic Science subject.

CHAPTER FOUR
PRELIMINARY DATA ANALYSIS

4.1 Introduction

The results of data analysis are presented in this chapter. The data that were collected at the beginning of the study were analyzed. The findings would achieve the aim of this study, which is to construct the requirement model for AR in Basic Science subject for pre-school. In addition, the results of this analysis would determine the requirements needed to create the model of ARMS in Chapter 5. Subsequently, the next topic will concern with methods used to collect the data.

4.2 Results of Data Collection

The information was gathered using several fact findings techniques; interview, observation and documentation review. Next subsection will list the results obtained from the data collection.

4.2.1 Interview

The respondents gave good responses to the implementation of AR in the proposed topic, which was the muscular system. According to the respondents, students basically will be taught on how to pronounce and what were the parts, the functions of body parts and health of the human body.

Besides, the teachers would make some preparations before classes using the latest and new methods besides the learning aids. The preparation lso helped the teachers to enhance the reading materials and encouraged the teachers to always be ready with other knowledge. In addition, the main problem often faced by the teachers during lessons when using learning aids such as the CDs as an intermediary teaching module was that the students would easily lost focus in during lessons. This became a barrier for the teachers to use the CDs as a learning aid because it was not able to attract the students. Therefore, AR technology is built as a solution to the problems.

Table 4.1 shows the results obtained from the interviews. Based on interviews carried out, the study found that the respondents were still unaware and unfamiliar with the existence of AR technology. The concept of education in this level is to introduce the fundamental topic as an early exposure to students. According to the respondents, students in preschools learnt fast because of their high level of attention and their easy learning attitude. This was an advantage to them because it was an early exposure that consisted of the fundamental aspects and encouraged the creative and critical thinking skills in order to assist their mental development.

Table 4.1: Interview Results

Interview schedule	**Interview question**	**Result analysis**
Respondents' experience in childhood education and usage of technology as a support tool in teaching	1. How long have you been in early childhood education?	All respondents had teaching experience in early childhood education of more than 10 years
	2. What are the childrens' characteristics?	• Like to play • Like to compete to get attention • Easy to memorize knowledge • Like to ask questions and interact with their friends • High curiosity, creativity, and imaginative • High ability to concentrate • Children are attracted to bright colours

		• The capability, efficiency and development of each stage are different even though they in the same level
To obtain the respondents' views and opinions on the Basic Science subject	1. What is the concept in early education?	• Develop the students' skill in 5 aspects which are social skills, intellectual skills, physical skills, spiritual skills, and aesthetic value • Develop positive attitudes as preparation before they enter primary schools • Children learn through play to involve their thinking, motivation, and socio-emotional development
	2. What is the concept in Basic Science subject?	• Students were actively involved in the science process skills • The process of engaging in observation, thinking, making hypothesis, reflection, action, comparison, measurement, exploration, relationship, communication, application and experimentation in the class activities • Situation raised curiosity, interest, investigate and learn to apply problem-solving skills to improve their knowledge
Teaching approach and characteristics objects that attract the preschool students	1. What are the teaching approaches used in human body topic?	According to the learning environment, various styles and methods of teaching in the classroom are important to ensure the teaching and learning is fun, effective, and meaningful. Thus, the various styles and methods will affect the cognitive development of the students. Here are some of the traditional methods used by teachers to teach the human body topic: • Singing • Painting • Chart display • Word card • Puzzles • Worksheets

		• ICT – use of CD • Follow teachers' movements
	2. Are there any themes used to teach the human body topics?	The Human Body topic is under the Theme Core Module. Basically, students will learn to recognize the body, learn the functions of the body, and healthy.
	3. Do you think anatomy is suitable to teach at this age?	To introduce the concept of the internal parts of the body as a basis can be implemented with the help of this technology
	4. What are the characteristics of the objects which should be focused to attract the students' attention?	• Colourful with the bright and vivid colours to stimulate the senses • Create the large elements and visually memorable • Use animated character • Create cartoon-liked design • Include printed pictures or elements because children like to have something tangible with them
AR technology and criteria commonly used as the support tools in Basic Science subject	1. Generally, what is the problem using technology as a learning tool in Basic Science subject?	• Students easily lost focus of the learning session that used CDs as a medium of teaching module • CDs supplied were damaged • Computer was often problematic and often damaged
	2. What are the advantages using technology as a learning tool in Basic Science subject?	• Teaching and learning are more attractive and more efficient • Teachers who use the technology as learning aids are more confident and able to describe ~~a~~ things more clearly
	3. Do you know about AR technology?	The respondents were still unaware and unfamiliar with the existence of AR technology
	4. Do you think AR	• Students were more interested and able to

	could be a support tool in teaching and learning sessions?	develop their minds ~~of~~ on human internal organs that were not available in the textbooks. • Teachers could add learning aids and also make preparations for classes with new technology.
5.	Why did you not teach anatomy to students before?	There were no suitable materials and support tools to teach anatomy.

4.2.2 Observation

This study used nonparticipant involvement technique (Kumar, 2005) in performing the observation. The purpose of nonparticipant observation was to determine whether the learning environment in the preschool classrooms using the AR is suitable or not. Thus, the researchers observed the class environments from three perspectives: position of students, learning space, and layout of Information and Communication Technology (ICT) equipment. Consequently, this study considers the demography and the learning environment as a point to gather information as below:

1. Demography: The total students per class were a clearly major factor to determine the typical information. The result was the average number of students per class is 22 students with a combination of boys and girls in class.

2. Learning environment: The researchers considered several factors such as safety, layout of class, ICT equipment and tools to implement AR. Basically, the physical classes for preschools are in groups. A minimum number was six students per group. This is an important situation to implement, conduct and

to control the class effectively using the AR technology. Thus, it is easy to implement AR with the minimum cost and safety.

4.2.3 Review Documents for Preschool Curriculum Standard

The purpose of reviewing the existing documentations was to gather background information and to understand the science curriculum in preschools. The results of the review are summarized in this section. This study has focused and reviewed three of the following documents:

1. The National Preschool Curriculum (MoE, 2001)
2. The Lesson Plan Preschool Documentation (MoE, 2011)
3. The National Preschool Standard Curriculum (MoE, 2011)

As a result, the aims of preschools are to increase the students' skills, self-confidence, positive attitudes while developing their potential, and integrates both of physical, spiritual, social and intellectual. It is based on the conducive learning environment, fun, creative and meaningful activities. It has several objectives in different perspective in the curriculums which are physical, emotional, intellect, spiritual, and social. However, this study has focused in achieving four intellectual objectives; i) basic science skills, ii) basic thinking skills and reasoning, iii) problem-solving skills, and iv) creativity and aesthetics. The design of the curriculum has been divided into two categories as follows:

1. Standard-Based Curriculum: This standard is formulated in the form of content standards and learning standards. The quality of learning should be

achieved as a standard determined by the MoE. The qualities consist of knowledge, skills, and values. It is to determine the criteria for ensuring the quality of learning and achievement for each content standard as shown in Table 4.2.

Table 4.2: Standard Content and Learning

	Standard Content	**Standard Learning**
Definition	Specific statement on what students should know and do regarding the qualities of knowledge, skills and value.	Fixed criteria or quality learning indicator and measurable achievement for each standard content.
Example 1: Cognitive development component	Classify the objects.	Classify objects according to size, colour, and shape.
Example 2: English Language Curriculum	Listen and recognize similarities in the sounds of language.	1. Identify words with the same beginning sounds 2. Identify words with the same ending sounds

In this study, students were exposed to one of the major systems in the human body known as a muscular system. The system consists of the heart, skeletal, and stomach. Students were introduced to the functions, health tips and disease for each type of this system. After the explanation and demonstration by the teacher, students explored this technology on their own and did the exercise. It was important to improve their understanding about this topic.

2. Modular-Based Curriculum: Modular curriculum is the curriculum content that is organized and then presented in the form of parts or units known as

modules. The Modular Based Curriculum is divided into two modules which are i) Basic Trust Module, and ii) Thematic Module. Table 4.3 summarizes the modular-based curriculum.

Table 4.3: Modular Curriculum

Basic Trust Module	
Language	Malay English Mandarin/Tamil
Basic Mathematic Islamic/Moral education Outdoor activity	
Thematic Module	
Essential Module	Language and Communication (Malaysia, Mandarin, and Tamil Language) Spiritual, Attitude and Moral (Islamic Education) Humanity Science and Technology Physical and Aesthetics Development Development of Personal Appearance
Example	Myself, my family, my body, my country, nature, animals

After reviewing the documents, the researcher found out that several aspects should be considered to construct the requirement model. It was to ensure the important guidelines as provided by MoE were adhered to. In addition, this study considered that this technology was able to provide the greatest impact in the teaching and learning sessions. Furthermore, this study emphasized on the thematic module. Each module for subthemes preferably includes the learning standards of essential elements in Table 4.4.

Table 4.4: Thematic Module for Purposed the Muscular System Subtheme

Theme: Human Body **Subthemes: Muscular System**				
Bil	Essential	Focus	Content Standard	Learning Standard
1	Language and Communication	BM 1.0: Listening Skill	BM 1.1: Listen attentively	• BM 1.1.7: Listening and respond to the instructions. • BM 1.1.13: Listen and respond to conversations, and the story.
		BM 2.0: Speaking skills	BM 2.2: Dialogue through the stimulus given.	• BM 2.2.4: In spontaneous dialogue. • BM 2.2.6: Submit appropriate questions and simple to understand. • BM 2.2.7: Answering question with a simple and appropriate sentence.
			BM 2.4: Telling the case has been heard.	BM 2.4.1: Telling the case has been heard by using simple verses.
		BM 3.0: Reading skills	BM 3.6: Reading the phrases	BM 3.6.2: Reading the phrase with the correct pronounce.
2	Development of Personal Appearance	PSE 2.0: Achieving a positive emotion.	PSE 2.3: Build the confidence to communicate.	• PSE 2.3.5: Asking with confidence. • PSE 2.3.6: Interacting with confidence.
		PSE 3.0: Build the social skills.	PSE 3.2: Using social skills in the interaction.	• PSE 3.2.2: Tolerant and cooperative during the activities. • PSE 3.2.9: Adjusting to circumstances or specific situation.
3	Physical and	PFK 1.0: Smooth	PFK 1.1: Doing smooth	• PFK 1.1.8: Cutting in the

	aesthetic	motor development	motor skills.	right way. • PFK 1.1.15: Cutting to produce a shape.
4	Science and Technology	ST 1.0: Scientific skill	ST 1.1: Showing the scientific attitude	ST 1.1.2: Showing the systematic attitude, cooperation, and responsibility.

4.3 Conclusion

Based on the analysis made, it can be concluded that there are three elements identified to develop the requirement model for this study. These elements include the users (teachers and students), review syllabus, and learning environment. The next chapter will discuss the construction of the the requirement model for the Muscular System for Learning in Muscular System (ARMS).

CHAPTER FIVE

THE PROPOSED MODEL: REQUIREMENT MODEL FOR AUGMENTED REALITY FOR LEARNING MUSCULAR SYSTEM (ARMS)

5.1 Introduction

Chapter 1 clearly discussed issues and problems related to learning the Basic Science subject and also identified the objectives of this research. As mentioned in Chapter 1, the second objective of this study is to construct the requirement model for Augmented Reality for Learning Muscular System (ARMS) for supporting teaching and learning Basic Science subject for preschool level. Subsequently, Chapter 3 described the methodology involved in this study to achieve the objectives. The methodology was divided into five phases; theoretical study, preliminary study, requirement model construction, ARMS development, and evaluation. As a result, this chapter provides detailed description of each component of the requirement model. The proposed model consisted of three main components; i) Requirement to Implement AR in Classroom (R-IARC), ii) High-Level Prototyping (HLP), and iii) Experiential Learning Model (ELM). This chapter provides the detailed description of these components.

5.2 The Proposed Requirement Model

The model has been designed to ensure the implementation of AR that has been correctly adapted to support the teaching and learning of the Basic Science subject in the classroom. As mentioned in Chapter 1, this study only focused on the human body topic. Figure 5.1 shows the proposed requirement model for ARMS. The model can be used to support Basic Science subject to preschool students. There are three main components of this model, namely R-IARC, HLP and ELM as described:

1. Component R-IARC

   The main purpose of this module is to ensure the implementation of AR that is matched with the Basic Science subject requirements. There are two interrelated modules; the Elements in Teaching and Learning Basic Science and Element of AR. The Elements in Teaching and Learning Basic Science module consists of four elements; user, syllabus, learning environment, and hardware and software. The results of data analysis have been analyzed to develop this module. Meanwhile, the hardware and software used in this study were ~~as~~ recommended by the Augmented Learning Environment (ALE).

   On the other hand, the second module, Elements of AR, was adapted from Bimber and Raskar (2005), previously described in Chapter 2. The purpose of the techniques and activities used in this module was to produce the AR product. This module was divided into two elements, which were fundamental and advance. The fundamental consisted of three techniques; tracking and registration, and display technology. The advanced elements included the toolkit representing the required activities. The detailed discussion of this component is included in Section 5.3.1.

2. Component HLP

   The second component is HLP. This component focused on design and developing AR objects based on the R-IARC. The contents in the ARMS prototype have been identified based on Elements in Teaching and Learning Basic Science module. ARMS prototype has been tested and validation by preschool students in order to ensure the readiness to use this technology in their learning environment. This component will be discussed further in Section 5.3.2.

3. Component ELM

   As mentioned in Chapter 2, ELM represented the four-stage learning cycle, namely Concrete Experience (CE), Reflect Observation (RO), Abstract Conceptualization (AC), and Active Experiment (AE). Each of the four ~~(4)~~ stages presented the emotional responses which were feeling, doing, watching and thinking. The purpose of adopting ELM as an indicator was to measure the acceptance of ARMS as a support tool in the Basic Science subject. The detailed discussion is in Section 5.3.3.

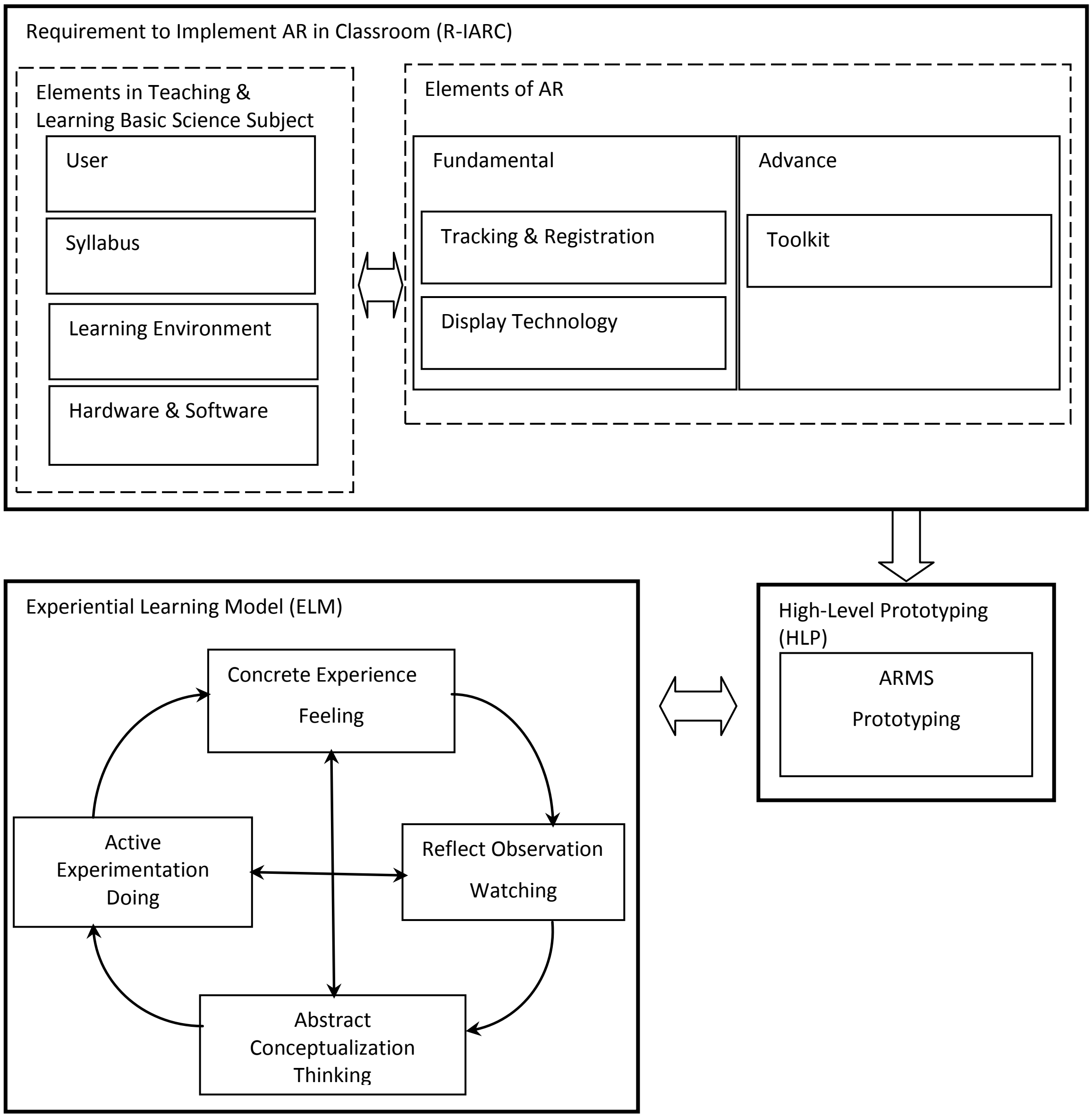
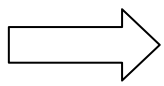
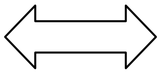
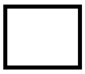


Figure 5.1: The Requirement Model of ARMS Component

Table 5.1 describes the notations used in this model.

Table 5.1: Requirement Model Notation

Elements	**Description**	**Notation**
Sequence Flow	Sequence Flow refers to the series of activity from start until the end of the activity	

AR Flow	ARMS Flow is a process where the blocks process dependencies with each other in an intersection of flow	
Component	A collection part that make up the ARMS	
Module	A self-contained component of an ARMS that defines the purpose	
Element	A method that has worked based on the characteristics	

5.3 The Components of ARMS

The ARMS requirement model consists of R-IARC, HLP, and ELM. This section discusses two components; R-IARCH and HLP. The next section will discuss the first component, R-IARC.

5.3.1 The R-IARC

This component is to ensure the implementation of ARMS in the classroom effectively. This component combines two modules; Elements in Teaching and Learning Basic Science Subject and Elements of AR. The first module depicts the six important components of AR and to relate it to Basic Science subject learning, the second module is constructed. The part of the requirement model has been supported by integrating both the modules. Figure 5.2 shows the R-IARC component.

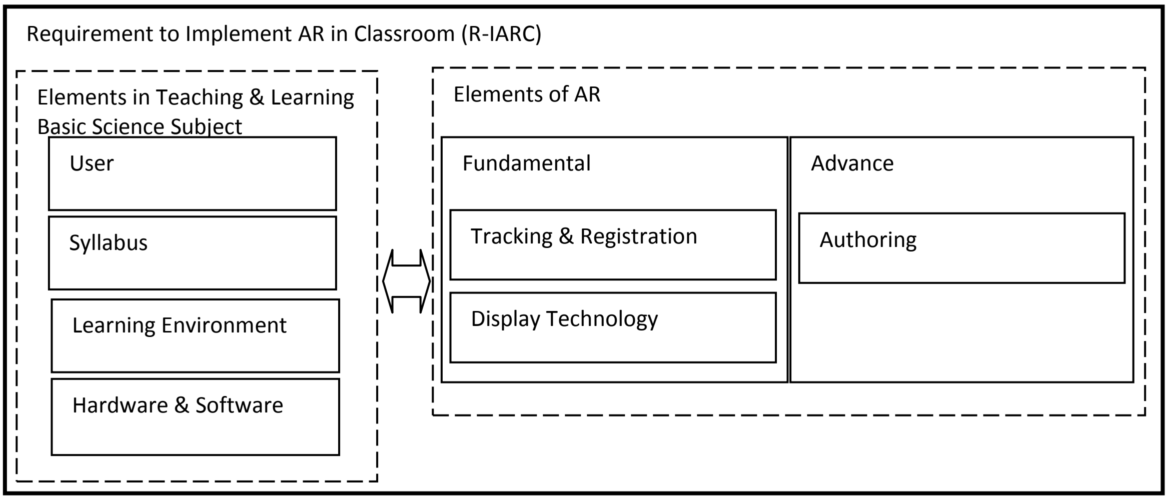


Figure 5.2: Regions that Exhibit Highest Population Growth

5.3.1.1 Elements in Teaching and Learning Basic Science Subject

Figure 5.3 shows the elements needed to be considered for effective implementation of the AR application as a learning aid for Basic Science subject. The elements are user, syllabus, environment, and hardware and software.

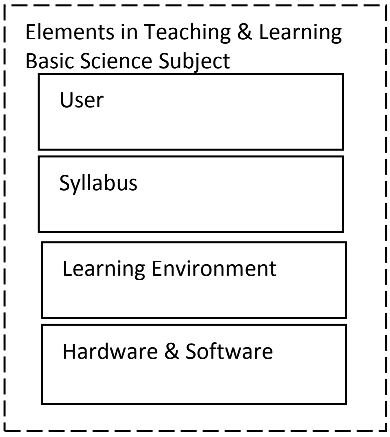


Figure 5.3: Requirement to Develop AR in Basic Science Subject

1. User

   Two categories of users were involved in this study, i) the expert teachers and ii) preschool students. The ARMS required the guide from teachers to teach the students about the muscular system. The teachers could monitor and teach their students using the AR application to ensure that they understood the topic that had been discussed. It also assisted the preschool teachers to improve the skill of teaching using technology approach and made the lessons more attractive and effective.

With the ARMS prototype, students would learn something new different from a book. The ARMS transformed static graphics from book to 'pop-up' three-dimensional (3D) virtual object with every perspective views. Students would be more interested to know the basis of muscular system inside the human body. Thus, it is easier for students to recognize the muscular system effectively and in an attractive way.

2. Syllabus

The purpose of reviewing the syllabus is to identify the related contents in achieving the objectives. The book for preschool students was a guideline and provided a minimum of teaching and learning to be implemented by preschools and they emphasize the outcome-based learning.

This study focused on the topic of the human body. The topic was interesting for students. The preschool students were familiar with individual bodies through their formal and informal lessons. However, the preschool students were not exposed to internal organs. Hence, this research was conducted to provide knowledge to students about the internal organs.

ARMS was developed with the aim to introduce and enlighten the students on the importance of internal organ. There are 11 major systems of the body, which are circulatory system, respiratory system, immune system, skeletal system, excretory system, urinary system, muscular system, endocrine system, digestive system, nervous system, and reproductive system. ARMS introduced one of the most important human internal organs known as a muscular system. It is an added value information for the preschool students.

The topic suggested was a muscular system fully supported by four expert preschool teachers. It was based on interviews conducted during the data collection process that was mentioned previously in Chapter 3. There are three different kinds of muscle, namely i) smooth muscle, ii) cardiac muscle, and iii) skeletal muscle. This study provided comprehensive notes to assist students to understand about the topic. The criteria designed for the preschool students were fun, easy to understand, attractive and has simple designs.

3. Learning Environment

According to Downes (2005), learning environment is the various styles and methods implemented in lessons. This study applied ALE based on the technology learning environment. The purpose is to ensure that the teaching and learning session becomes fun, effective and meaningful. It will affect the cognitive development of the students.

Based on the interviews conducted, there were several methods used by teachers to teach the topic. Most of these methods used for teaching and learning in Basic Science subject were paper-based. Thus, ALE provided the conducive for learning, allowing students' space and interaction in the learning and teaching process. The drawback was students just viewed the static graphics on the paper.

Therefore, ARMS was able to solve the paper-based problem in the teaching and learning of Basic Science subject because it emphasized on the concept of visualization. Hence, students were able to visualize the muscular system. The other benefit is to improve and empower the tools for teaching and learning session. It became more attractive and fun for the students to learn the muscular system.

4. Hardware

   The Augmented Learning Environment (ALE) proposed by Whalley, Welch & Williamson (2006) was chosen in this study because it consisted of some minimum devices to implement ARMS in the classrooms. The equipment in this study had also been considered in terms of cost and minimum hardware to make it suitable to use in the preschools. Figure 5.4 shows the hardware used in this study.

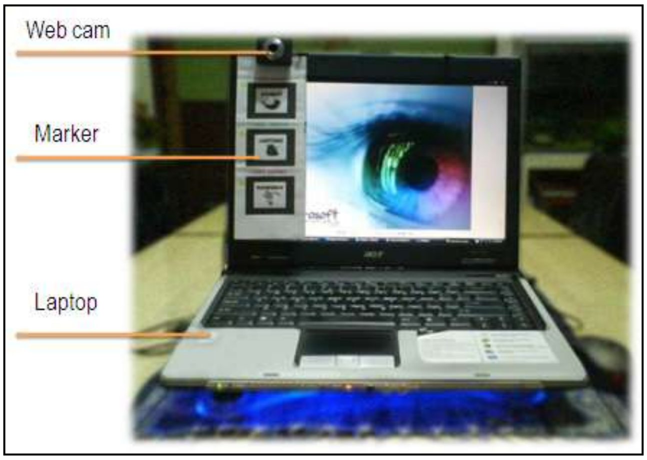


Figure 5.4: ARMS Hardware

a. Webcam: Webcam is used to capture images, detect and track the marker on ARMS. It is important to overlay the 3D virtual objects correctly based on the ID marker. The model of this webcam was Ice Blue. The product specification is 1300K pixels, Video capture resolutions up to 640 x 480, 24 digit of colour, sensor type CMOS 1300k, interface using USB and video frame rate up to 38 frames.

b. Laptop: The specification of this laptop is 3GB RAM, 80GB HDD. The processor is Intel Core Duo Processor T2300E (1.66GHz, 66 MHz FSB, 2 MB L2 cache). The operating system installed is Microsoft Windows XP version 2002.

c. Marker: The marker is an essential element for system tracking. The marker-based AR was to determine the centre, orientation and range of its spherical coordinate system. Three markers, including the stomach, heart and skeletal were designed for use in the ARMS prototype. The marker design has combined the text and image objects. The students are required to show the marker on the webcam to view the virtual objects.

5. Software

   Software used in the ARMS development phase was ARToolKit, Microsoft Visual Studio, and 3D Studio Max 7 (3DS Max 7). ARToolKit is a software library for building AR applications. This prototype used ARToolKit version 2.72 with Virtual Reality Modeling Language (VRML) support to incorporate the AR options. It used Microsoft Visual Studio C++ version 6.0 as a development environment. The 3D model was constructed using 3D Max version 7. The software was used to create 3D model, animation, rendered and the model were exported to VRML format.

Figure 5.5 summarizes the relationship between these elements. The users involved in this study were teachers and students. This study focused on Basic Science subject for preschool and it covered the human body topic, which consisted of the muscular system as a subtopic. ALE is applied in the classroom. According to the ALE recommended, the hardware used in this study were a webcam, marker and the laptop. The software used to develop ARMS was ARToolKit 2.72 as a toolkit to build the prototype, 3DS Max 7 to create the 3D object and also Microsoft Visual Studio 6.0 as a development environment.

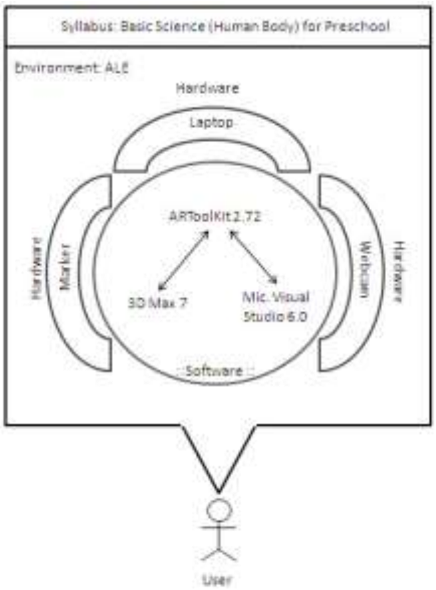


Figure 5.5: Requirement Design to Develop ARMS

5.3.1.2 Elements of AR

Figure 5.6 presents the Elements of AR. For this part, the model adapted the elements suggested by Bimber and Raskar (2005). This model was required to accommodate the AR integration into the Basic Science subject which was mentioned in Chapter 2. Thus, a modification model has been developed based on their model. The block of the components was divided into two parts, which are i) fundamental components, and ii) advanced components. The original basic contents were tracking and registration and display technology. The original advanced components involved an interaction device and techniques, presentation and authoring.

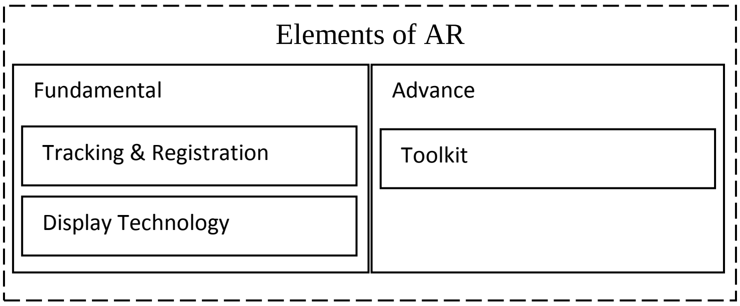


Figure 5.6: The Elements of AR

1. Fundamental components

   Figure 5.7 illustrates a relationship between the elements in ARMS. As discussed in Chapter 2, the fundamental elements which included tracking and registration, display technology and rendering, were described from the challenges found in AR technology. The tracking and registration was to ensure and establish the head position during movement activities. It also determined the position and the orientation of the objects in the real world (Sinclair, 2004; Bimber & Raskar, 2005). Then, the graphic system could draw the virtual image in the correct place based on the information provided by the tracking system. Finally, the display systems were supposed to acquire the correct information with the combined real world and the virtual object to determine the user's position in real time. Head mounted display (HMD) was a display technology device that has been widely used in a virtual environment. This study had limited budget to use HMD. Thus, it used webcam as an alternative display technology in ARMS.

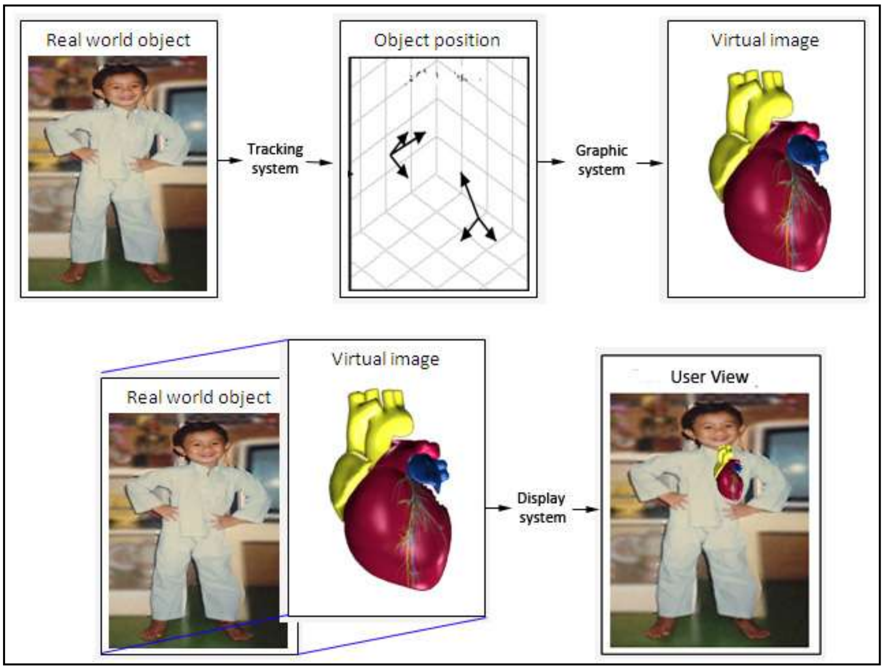


Figure5.7: Relationship between Virtual Object and Real World (Adopted: Sinclair, 2004)

The third fundamental element is real-time rendering. The purpose of rendering is to ensure that the virtual object was more realistic to integrate into the real environment (Bimber & Raskar, 2005). However, this study did not apply the rendering technique because the internal part of muscular system did not require real-time rendering. This was supported by Bimber and Raskar (2005) who wrote that not all AR application require a rendering element and it is based on the situation (Bimber & Raskar, 2005).

2. Advance components

According to Bimber and Raskar (2005), the original module consisted of three elements, namely interaction devices and techniques, presentation techniques and authoring tools. However, this study did not apply the elements of interaction devices and presentation techniques because the

ARMS prototype applied video-based techniques without any interaction device. Meanwhile, the element of authoring has been replaced by the toolkit.

ARMS used ARToolKit in its development of a prototyping process. Three virtual objects used in the ARMS were heart, stomach and skeletal known as muscular system. These objects were stored in the library in the VRML format. The objects generated for this study can be reused for another study.

5.3.2 The HLP

Basically, in this conceptual diagram of AR, the objects represent the overlay graphics generated by the camera. Simple descriptions on AR work are illustrated in Figure 5.8 as follows:

1. The virtual object represented the overlay graphic onto camera image.

2. The camera captured the video of the real world and sent it to the computer and detected the correct square shapes on the marker.

3. The virtual objects of ARMS have been stored in the library and appeared overlaid on the real environment through the laptop.

However, the limitation of this study is using the lower resolution webcam with factors that may affect the quality of virtual objects. The other factor was the virtual object would disappear when users covered up the pattern on the marker.

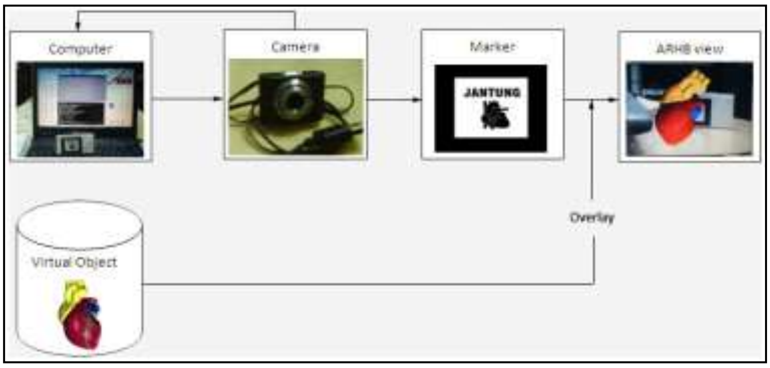


Figure 5.8: ARMS Process Summarization

According to Figures 5.8 and 5.9, the high-level of ARMS prototype has been developed based on the process to generate ARMS mentioned earlier.

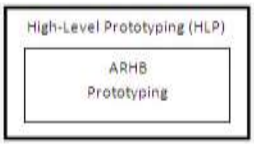


Figure 5.9: Prototype Development Based on the Design

5.3.2.1 ARMS Prototype Design and Development

As mentioned previously, the design and development phases of the ARMS prototype were based on the proposed model. The ARMS prototype of the muscular system was produced. There were four tools to produce the prototype of ARMS consisting of the ARToolKit, marker, 3DS Max and a comprehensive note.

1. ARToolKit 2.72

   ARToolKit is a C and C++ language software library to develop AR applications. This is a collection of software libraries. It was distributed as a source code and users needed to compile it on their system. ARToolKit can be implemented in the multiplatform operating system. This ARMS prototype used the ARToolKit version 2.72 with VRML support to incorporate AR options. This prototype used the Windows XP as operating system. Table 5.2 describes the requirements to build ARToolKit on Windows environment, while Figure 5.10 displays the steps to build ARToolKit in laptop.

Table 5.2: Building ARToolKit on Windows (Adopted from HitLabNZ, 2002)

Requirement	**Instruction**
Development Environment	Microsoft Visual Studio 6.0 was used in the ARMS development process. Windows XP was used as operating system that has already been installed.
DSVideoLib-0.0.8b-win32	DSVideoLib was used to handle communication with the camera driver.
GLUT	GLUT is OpenGL Utility Toolkit. Verify that GLUT runtime and SDK is installed. Verify the GLUT runtime installed in system directory. • c:\windows\system32\glut32.dll Verify that GLUT SDK is installed in Visual C++ installation: • Include\gl\glut.h • Lib\glut32.lib
DirectX Runtime	Verify that DirectX runtime is installed
Video input device	Plug webcam into laptop
OpenVRML-0.14.3-win32	ARMS used OpenVRML-0.14.3-win32 to export 3D model into VRML format

You can now build ARToolKit. Build steps:

1. Unpack the ARToolKit zip to a convenient location. This location will be referred to below as {ARToolKit}.
2. Unpack the DSVideoLib zip into {ARToolKit}. Make sure that the directory is named "DSVL".
3. Copy the files DSVL.dll and DSVLd.dll from {ARToolKit}\DSVL\bin into {ARToolKit}\bin.
4. Install the GLUT DLL into the Windows System32 folder, and the library and headers into the VS platform SDK folders.
5. Run the script {ARToolKit}\Configure.win32.bat to create include/AR/config.h.
6. Open the ARToolKit.sln file (VS.NET) or ARToolkit.dsw file (VS6).
7. Build the toolkit.

The VRML renderering library and example (libARvrml & simpleVRML) are optional builds:

8. Unpack the OpenVRML zip into {ARToolKit}.
9. Copy js32.dll from {ARToolKit}\OpenVRML\bin into {ARToolKit}\bin.
10. Enable the libARvrml and simpleVRML projects in the VS configuration manager and build.

Figure 5.10: Steps to Building ARToolKit on the Windows Environment (Adapted from HitLabNZ, 2002)

2. Marker

The initial process was to design and create the image for each marker followed by two principles in Multimedia Learning Theory, which are spatial contiguity and multimedia. The image on the marker was produced using Adobe Photoshop CS4 and stored in the Joint Photographic Experts Group (.jpeg) format. Figure 5.11 illustrates the storyboard design for markers and Figure 5.12 shows the ARMS marker.

TITLE: HEART MARKER

SCREEN: 1

FUNCTIONALITY/INTERACTIVITY: MARKER DETECTATION

BACKGROUND: WHITE

COLOR SCHEME: BLACK AND WHITE

AUDIO: -

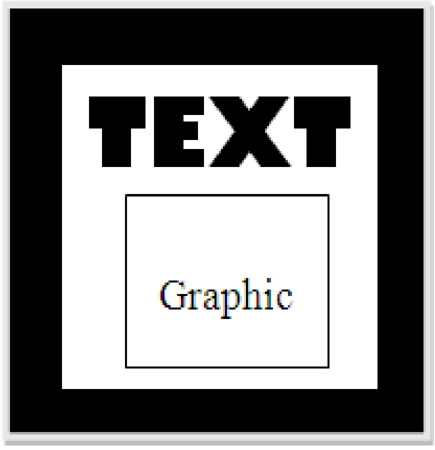
VIDEO: -

TEXT ATTRIBUTES:

I. Size : 36
II. Typeface : Gill Sans Ultra Bold
III. Type : San Serif
IV. Color : Black

GRAPHIC:
I. Color : Black and White

STILLS: STATIC



VERSION: HeartMarker_ver1 DATE : 1 Mac 2009

NOTES:Spatial Contiguity Principles

Figure 5.11: Marker Storyboard

Figure 5.12: The Three ARMS Markers

In order to identify the pattern, the code must be set as shown in Figure 5.13. Thereafter, the bitmap image will recognize the pattern through mk_patt file.

```
char        *cparam_name    = "Data/camera_para.dat";
ARParam      cparam;

char        *patt_name      = "Data/patt.jantung"; //<<guna namafail yg save>>
int          patt_id;
double       patt_width     = 80.0;
double       patt_center[2] = {0.0, 0.0};
double       patt_trans[3][4];
```

Figure 5.13: Codes to Identify the Pattern

Figure 5.14 shows the mk_patt programme asking to camera parameters. At this stage, press the Enter key and the property sheet will pop up the details of the video format as shown in figure 5.15. In the video dialogue, the user would select the output size of the video. Figure 5.16 demonstrates the webcam pointing directly in front of the pattern until the colours of red and green appeared. Then, click the left mouse button and then save the same filename shared with the code that identified the pattern as shown in Figure 5.17. Once a filename has been entered, the bitmap image of the pattern was created as shown in Figure 5.18. The filename for this study was named patt.jantung for cardiac, patt.perut for stomach, and patt.rangka for skeletal. This was used for pattern matching in ARToolKit.

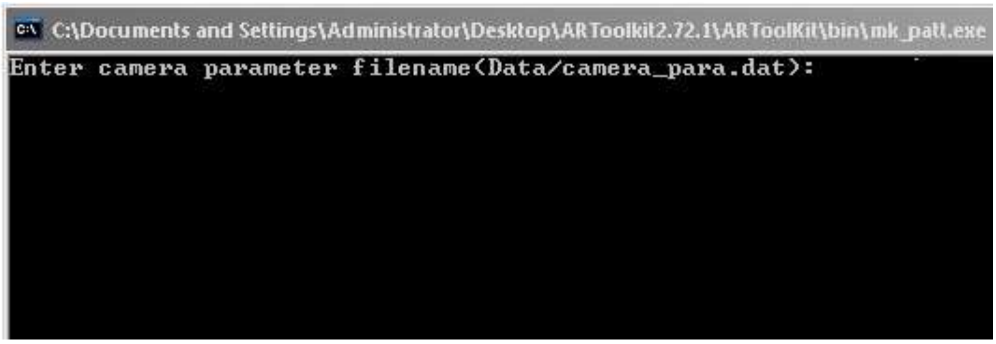


Figure 5.14: mk_pattern Programme

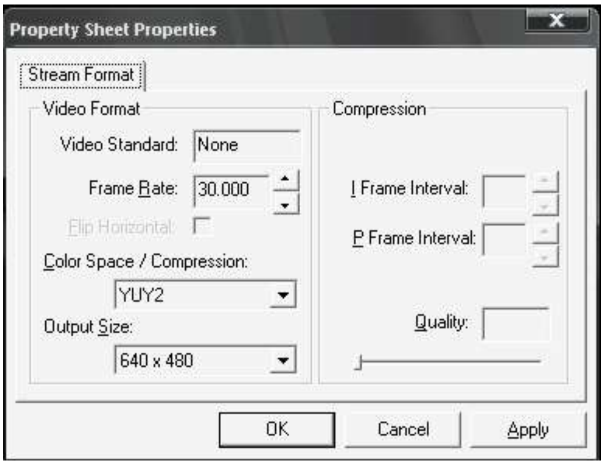


Figure5.15: Windows Camera Configuration

Figure 5.16: The mk_patt to Recognize the Pattern Until Red and Green Colours Appeared

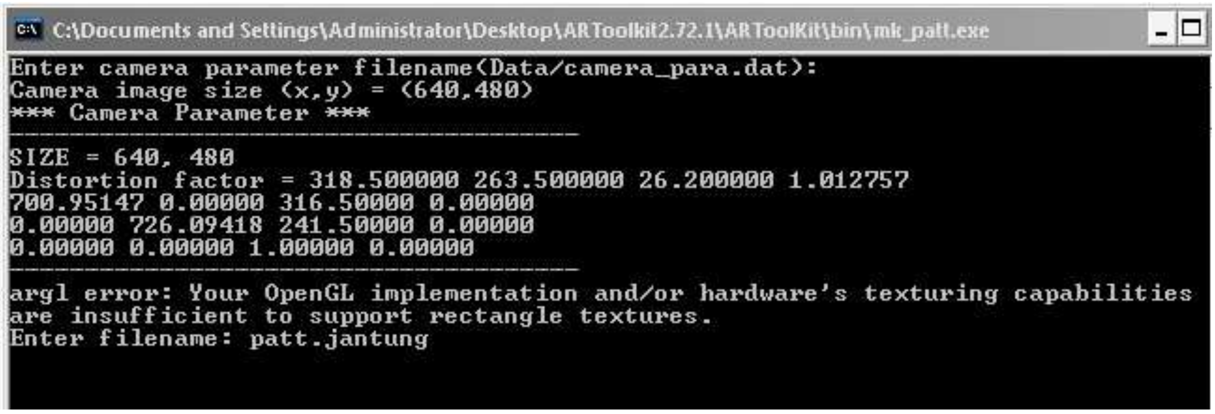


Figure 5.17: The Prompt to Enter the Filename of the Pattern

Figure 5.18: ARToolKit Pattern for Matching with the Virtual Objects

ARMS prototype tracked by using multiple patterns with different 3D objects. Thus, each marker in ARMS must be specified and structured for each object as shown in Figure 5.19. Once opened in the Notepad++, the text stated the number of patterns to be recognized. The VRML files contained information on pattern name, file name recognition pattern, width of tracking the marker and centre of tracking the marker.

3. 3DS Max 7

After the required data gathering was conducted, the virtual objects were designed according to the coherent principles in Multimedia Learning Theory. Figure 5.20 shows the design and development of the objects requiring storyboard as a guideline. Storyboardschool.com (as cited in Noraina, 2005) lists several format of a storyboard:

a. A sketch of drawing of the screen, page, or frame
b. Colour, placement, and size of graphics (if important)
c. Actual text, if any, for each screen, page or frame
d. Colour, size and type of font (if there is text)
e. Narration, animation, video, audio and audience interaction (if any)

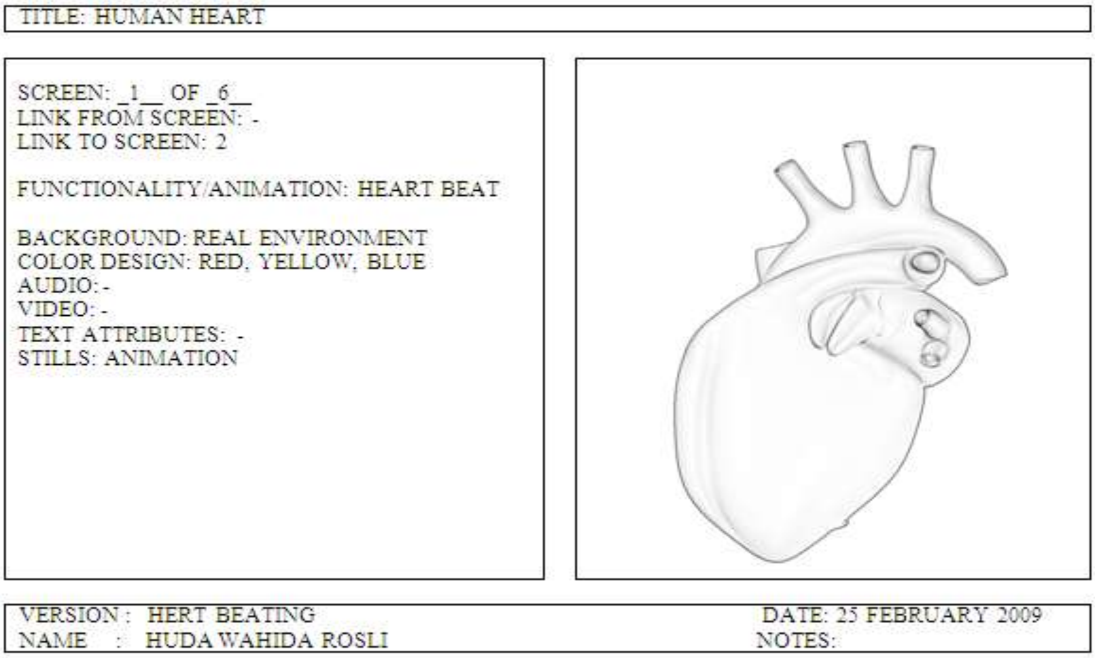


Figure 5.20: Cardiac Muscle Storyboard

Figure 5.21 illustrates the process of creating 3D muscular system objects to produce virtual objects in Virtual Reality Modeling Language (VRML) format.

a. Construction of the 3D model

The 3D model was constructed using 3DS Max 7. It used several modified techniques to make the 3D objects smooth.

b. Add texture, animation, lighting, and camera

3DS Max 7 provided mapping, animation, lighting and camera to produce the quality objects. The animation for the muscular systems was set in 3DS Max 7 with the controller to ensure that the movements were balanced.

c. Render

The purpose to generate renderings was to view animated objects. The output was based on the modeling, animation, texturing, lighting and camera set in 3D Max. The rendering process was influenced by time depending on the factors that causes the process to be slow such as using the big polygon counts. In render mode, the object was displayed in actual form. If the object created was satisfactory, it was ready to be converted into VRML format.

d. Convert to VRML format

This file should be exported to VRML format that is available in 3DS Max 7. This study used VRML97 file format.

e. View VRML via CosmoPlayer

CosmoPlayer was made available as a service to the Web3D and Supports VRML97. After exported to the VRML file, it can be opened in the CosmoPlayer.

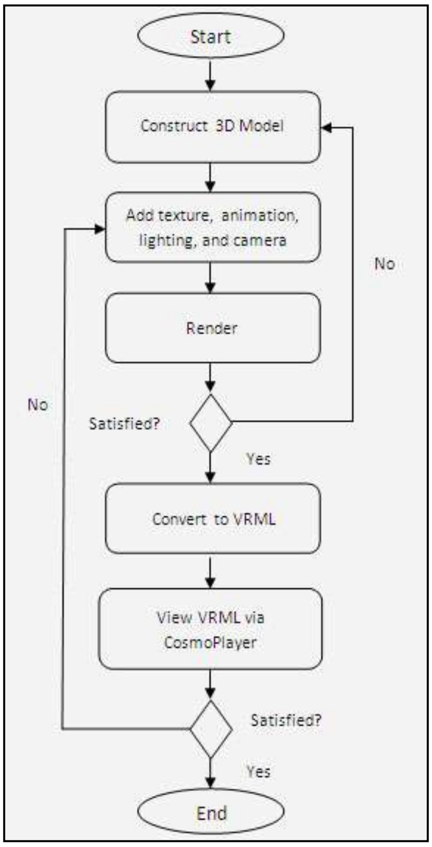


Figure 5.21: Steps to Produce Virtual Objects in VRML Format

Basically, there are four main processes to produce ARMS object in 3D, which are modeling, animating, texturing and rendering. The 3D modeling was carried out using 3DS Max 7. Objects were created in the viewport as presented in Figure 5.22. This has used several modified techniques to make the 3D objects smooth.

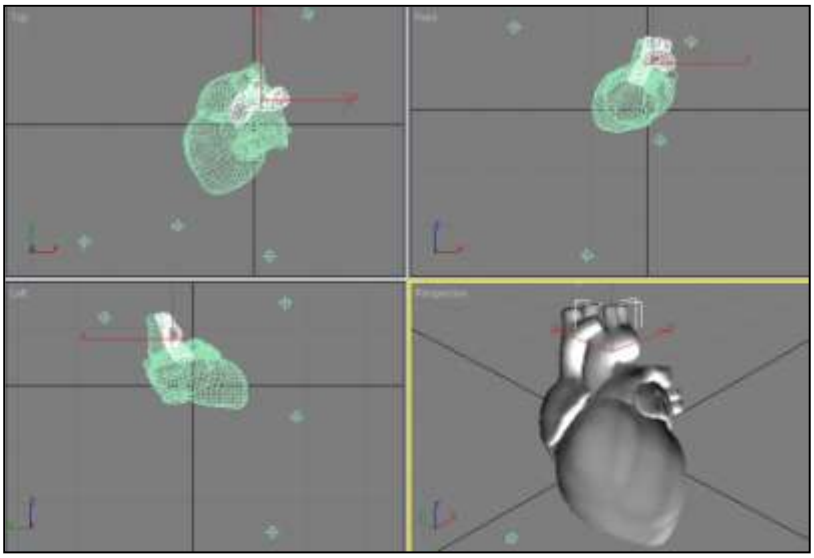


Figure 5.22: Viewport to Create the Objects

The surfaces of the objects were enhanced with material which was created and edited in Material Editor and mapped to the objects in the scene. Several aspects were considered during the mapped process such as ambient colour, diffuse colour, glossiness, opacity and self-illumination. Figure 5.23 shows the mapped to the object.

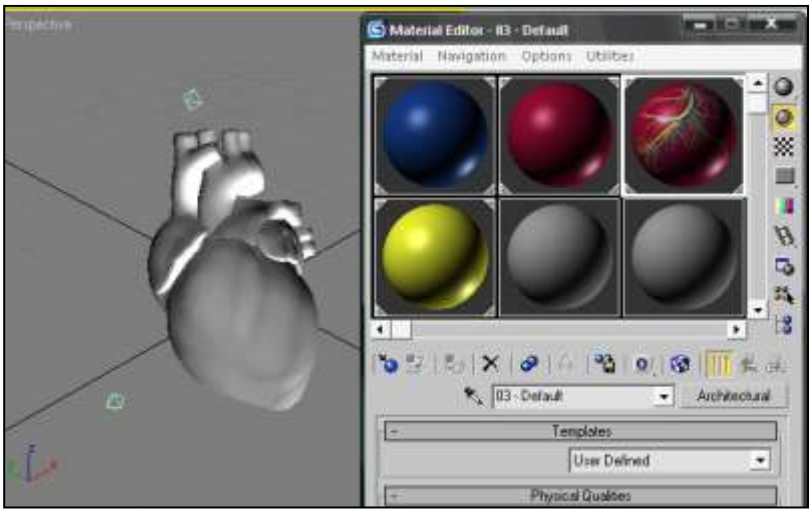


Figure 5.23: Mapping the Object

Once the object was prepared with the lighting and cameras in place, the object was ready to be set in motion by creating key frames animation. The technique of 'controlling animation' was applied in ARMS objects. The purpose of this controller was to ensure that any animation movements in the object are balanced as displayed in Figure 5.24.

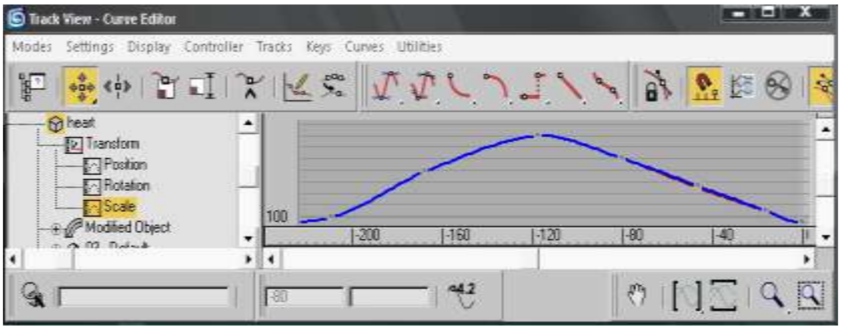


Figure 5.24: Movement Controller

By applying 'parameter curve out-of-range type' technique, it was able to repeat a number of keys without having to multiply the key as appeared in Figure 5.25. The advantage of applying this method was that changes made would affect the entire animation of the objects.

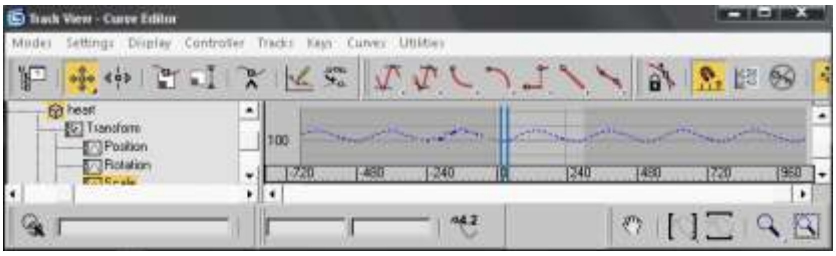


Figure 5.25: Parameter Curve Out-of-Range Type Technique

The purpose of renderings is to view objects made by animation. The output was based on the modeling, animation, texturing, lighting and camera set in 3D Max. The rendering processing time depended on the above factors that could slow down the process. Figure 5.26 shows that each frame has its own processes and is stored in the Audio Video Interleave (.avi) format.

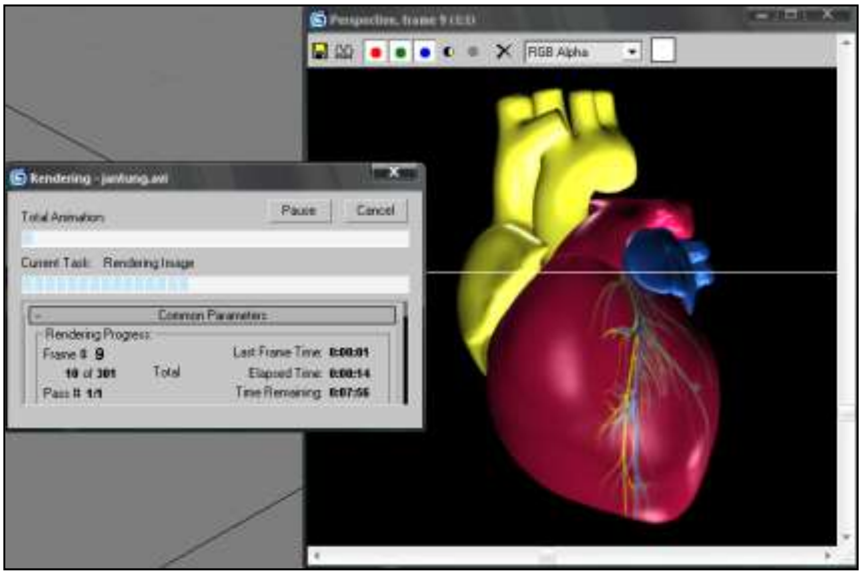


Figure 5.26: Rendering Process

These object files are stored in the 3DS Max 7 format (.max). Then, this file should be exported to VRML format as illustrated in Figure 5.27. Translation from .max to VRML97 (.wrl) supported 3D model, animation, lighting-direct, omni and spot, camera-free. However, this study has a limitation on this VRML.

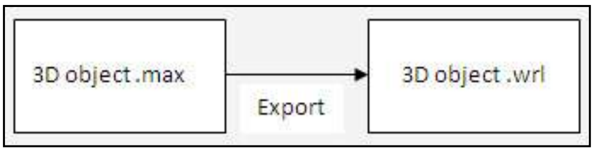


Figure 5.27: Translation Process to VRML

4. Comprehensive notes

The design of comprehensive notes is to help improve the presentation. Besides that, this comprehensive note acts as a tool that helped preschool students to understand the muscular system.

To design the comprehensive notes, the fonts, graphics and layout aspects used need to be considered. Jamalludin and Zaidatun (2000) suggested using large fonts for youngsters, and simple text to ensure that the font is easy to read and consistent. For the layout, Multimedia Learning Theory consisted of coherence, spatial contiguity and multimedia is applied as mentioned in Section 2.5.2.

In addition, CASPER designed principles were used as a guide to organizing media such as text, graphics, animation and video at a presentation which may stimulate the attention and audience. Figure 5.28 shows the principle layout of the CASPER abbreviation. Figure 5.29 illustrates the principles of coherence, spatial contiguity, multimedia and CASPER was applied to design the storyboard for comprehensive notes.

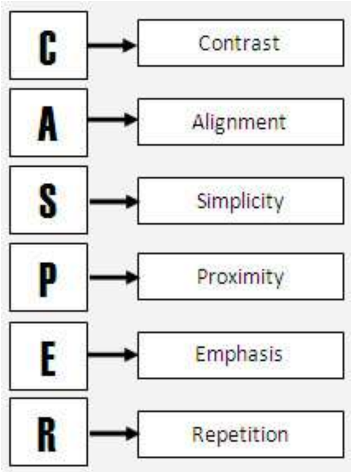


Figure 5.28: CASPER Principles

a. Contrast: The function of contrast was to show the differences between objects. In designing this comprehensive note, the use of colour was used to distinguish between the contents and the background. In addition, text, colour and line were used to show the differences between the content.

b. Alignment: Each graphic element was arranged to balance the weight of each part of the interface for the graphics to appear. This principle was applied on every page of ARMS comprehensive note to make it consistent.

c. Simplicity: This comprehensive note used the simple and meaningful graphics. In addition, it also applied short texts for each sentence.

d. Proximity: Proximity item was emphasized by listing each title on every page. This was to facilitate the users to recognize the continuity that existed between each topic. In addition, the position of each subtopic was placed in one part.

e. Emphasis: Using text and graphics to emphasize attention on the contents.

f. Repetition: The principles of repetition were applied to the text elements. They were also illustrated by graphics.

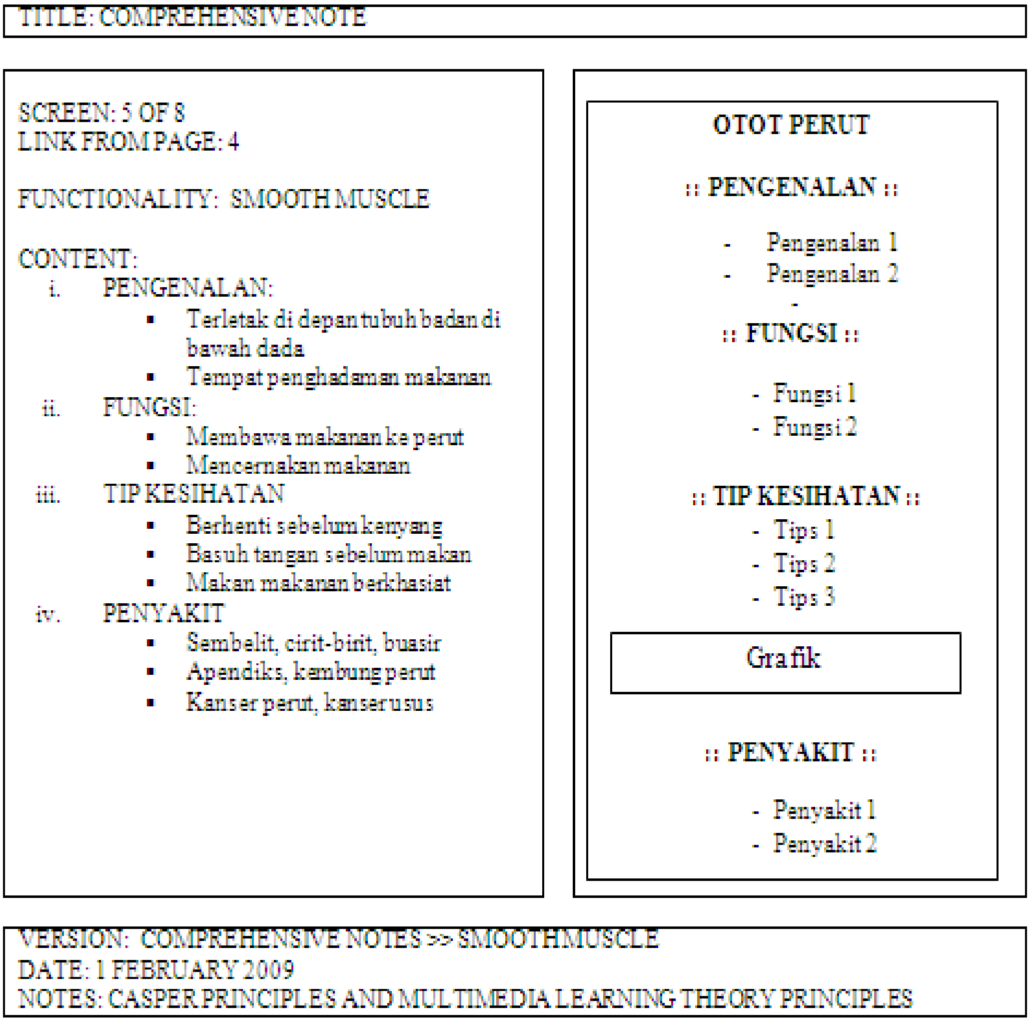


Figure5.29: Storyboard for Comprehensive Notes

Figure 5.30 shows the comprehensive note design.

Figure 5.30: The Interface of Comprehensive Note for Smooth Muscle

5.3.3 Experiential Learning Model (ELM)

As mentioned in Section 2.7, ELM provided four-stage cycles, namely Concrete Experience (CE), Reflecting Observation (RO), Abstract Conceptualization (AC) and Active Experimentation (AE), which had two dimensions known as Processing Continuum for east-west axis while the north-south axis is known as a Perception Continuum. Thus, the adoption of ELM is described as follows:

1. AC: Listening to the explanation on the topic by their teacher.
2. CE: Going step-by-step through the comprehensive note that was given to students.
3. AE: Practicing using ARMS prototype.
4. RO: Testing students using ARMS exercises.

5.4 Evaluation Sessions

The evaluation session was conducted in four government preschools as mentioned in Section 3.3. This evaluation involved four expert teachers and 88 students. Table 5.3 shows the evaluation process for ARMS in the control group, while Table 5.4 shows the evaluation process for the experimental group. All selected users used the ARMS prototype. After completing the activity using ARMS, the researcher conducted the unstructured interviews with students to get their opinions on ARMS.

Table 5.3: Implementation Process in Control Group Stage

Steps	Student content	Activities		Support tool
		Teaching (Teacher)	Learning (Student)	
Introduction	Teachers started the class with the students' attention on the human body.	Teachers began the lessons by asking students about their knowledge of the body and internal organs that they knew.	Students answered the teacher's questions with their existing knowledge	• Human body picture
Set induction	Teachers attracted their students with the pictures of the muscular system.	1. Teacher explained the general of the muscular system. 2. Teacher showed the the location of the muscle system. 3. Teacher explained the function of each muscle system. 4. The teacher explained how to take care of their muscular systems. 5. Teacher provided examples of diseases that have high morbidity and mortality.	1. Students were able to give full attention in learning session. 2. Students held their own body 3. Students gave full attention and interacted with the teacher when the teacher explained the functions, the healthy tips, and examples of diseases of muscular system.	• Muscular system picture • Human body picture

Table 5.4: Implementation Process in Experimental Group Stage

Steps	**Student content**	**Activities**		**Support tool**
		Teaching (Teacher)	Learning (Student)	
Preimplementation	Teachers attracted students by giving the comprehensive notes, and markers.	1. Teachers encouraged the students to recall the muscle system using the comprehensive notes. 2. Teachers encouraged students to spell the letters and identified the object appeared on each marker.	1. Students participated in activities and interacted with each other in class. 2. Students spelt the letters and identified the objects appeared on the markers.	• Comprehen-sive notes • Marker
Implementation	Teachers attracted students by using the ARMS prototype	Teachers demonstrated the ARMS prototype while interacting with them	Students tried themselves and interacted with teachers and their friends.	• Marker • ARMS Prototype
Post-implementation	Teacher distributed the ARMS exercises to students.	Teacher gave instructions to complete the exercise sheet provided.	1. Students learned to follow instructions and complete their exercise. 2. Students who have completed the exercise are require check the answer using ARMS 3. Researcher	• ARMS exercises • ARMS prototype

conducted the unstructured interview with students.

Figures 5.31 to 5.36 show the evaluation sessions at preschools.

Figure 5.31: Teacher Showed General Anatomy in a Control Group Session

Figure 5.32: Teacher Explained About Muscular System Using Comprehensive Note in an Experimental Group Session

Figure 5.33: Teacher Demonstrated ARMS in an Experimental Group Session

Figure 5.34: Students used the ARMS Themselves in an Experimental Group Session

Figure 5.35: Students Completed the ARMS Exercise in an Experimental Group Session

Figure 5.36: Students Who Have Completed the Exercise Checked Their Exercise in an Experimental Group Session

5.5 Conclusion

This chapter began with the definition for each component of ARMS. The proposed requirement model of ARMS was to support the teaching and learning of Science subject at preschools. The components of ARMS were divided into R-IARC, HLP and ELM components.

This requirement model has a guideline to develop the ARMS prototype. In addition, this chapter discussed the process involved in producing the ARMS prototype. It involved ARToolKit version 2.72, marker and 3DS Max 7.

CHAPTER SIX
EVALUATION OF PROPOSED SOLUTION

6.1 Introduction

This chapter discusses the results of verification and validation for the requirement model of Augmented Reality for Learning Muscular System (ARMS). The verification of this model was conducted by using expert reviews to gain comments and suggestions for improvement. The ARMS prototype was developed based on the proposed requirement model. Subsequently, the validation process was to ensure the acceptance of this technology to be implemented in the preschool environment as a support tool.

6.2 The Verification for Requirement Model of ARMS Result

The experts were identified from two different categories; the i) teachers who have at least ten years of experience in teaching the Basic Science subject and ii) the AR technology experts (refer Appendix K). They were required to evaluate the correctness and completeness based on the requirement model for ARMS based on components, modules, and elements included in the model. The detailed explanation of the requirement model is discussed in Section 5.2.

The verification process was carried out by a survey consisting of three main stages as shown in Table 6.1:

Table 6.1: Verification Process

Stage	Description
Preparation	1. Identify the experts from the Basic Science teachers and AR area. 2. Prepare two different verification forms for each category of experts. 3. For the interview, conduct a briefing session to explain about the project, verification process of the requirement model. 4. For the survey, email the experts.
Execution	1. Distribute the verification form to the experts via face-to- face and email. 2. Demonstration of the prototype. 3. The experts completed their task after three explanation sessions between them and the researcher. The other experts completed their task by sending the completed form via email. 4. The experts review the requirement model of ARMS. For interview, the experts discuss with the researcher regarding the requirement model to clarify the requirements.
Refinement	1. Collect feedback from the experts. 2. Analyze the feedback obtained from the experts. 3. Improve the proposed requirement model based on the feedback.

In general, some corrections were made based on the feedback received by the experts such as the previous model did not clear between components or elements, thus arrows have been created. In other example, the previous model used the authoring elements. However, based on the expert suggestion, the elements changed the toolkit to develop ARMS application.

In addition, respondents stated that the model can be workable and able to produce effective teaching and learning style. They also responded that the proposed model provides simple steps that can be easily used and applied for preschool level. The next subsection discusses the results according to the expert teachers and AR experts.

6.2.1 Basic Science Teacher Review

The aim of this process was to ensure that the content of the requirement model matches the syllabus of the Human Body topic. This process involved four experts who are teachers of the Basic Science subject. The experts were required to check the components on the Elements in Teaching and Learning Basic Science Subject and the adoption of Experiential Learning Model (ELM).

The review of requirement model of ARMS comprises of three stages as follows:

1. Identify the requirement model of ARMS: Once the process has been done to initialize the expert teachers and briefing session to explain about the AR technology and requirement of ARMS, they are required to ensure the elements are correct based on their experience in the Basic Science subject.

2. Review the requirement model of ARMS: All expert teachers were asked to comment on the following Elements in Teaching and Learning Basic Science Subject, which are i) user, ii) syllabus, iii) learning environment, and iv) hardware and software and also ELM. They are required to check and verify the elements are specific, correct, complete, and workable.

3. Verification the requirement model: The verification was based on their experience in teaching the Basic Science subject using the technology approach. The experts are able to modify the elements to suit the requirement model if the components, elements, or modules are not suitable to be implemented in the preschool environment.

Each stage complements the previous one, and ensures that the process as a whole is thorough using the face-to-face approach. The required duration to conduct the survey is two days for each expert teacher. Table 6.2 summarizes the expert teachers' feedback.

Table 6.2: Expert Teachers' Feedback

Respondents	**Experienced (Year)**	**Elements**	**Comments and Suggestion**
Respondent 1	18	User	Add assistant teachers to improve teaching and learning process.
		Syllabus	The worksheet or exercise as reinforcement should be added.
		Learning Environment	AR able to attract the preschool students' attention using attractive objects, for example colour and animated object.
		Hardware and Software	The list of hardware is suitable to use for preschool students. The prototype as you demonstrate, practicability to implement for preschool level.
		ELM	The ELM learning style is suitable for this activity. The model is also suitable for preschool students because it is complete to analyze their understanding of the muscular system.
Respondent 3	17	User	Need to involve the assistant teachers to ensure the teaching and learning process runs smoothly.
		Syllabus	Teaching and learning based on

			experiments is more suitable to help students understand and make the lesson meaningful.
		Learning Environment	Teaching and learning based on experiment is able to improve the students' understanding.
		Hardware and Software	The hardware is simple and easy to use for preschool students.
		ELM	ELM is able to assist the cognitive development using technology as a support tool in teaching and learning sessions.
Respondent 4	18	User	Add assistant teachers to improve teaching and learning process.
		Syllabus	Your study is suitable to introduce muscular system for preschool students because you just introduce the basics of the system.
		Learning Environment	Need to use a variety the themes for this topic to make teaching and learning becomes fun and meaningful.
		Hardware and Software	The hardware is suitable to implement ARMS in classroom. The prototype is appropriate for preschool student.
		ELM	The ELM currently is suitable to implement with this prototype. ELM is able to assist the students' cognitive with the four-phase skills. Students understand the

			suggested topic easier.
Respondent 5	11	User	Need to add assistant teachers to improve the teaching and learning process.
		Syllabus	The basic muscular system is suitable to introduce for preschool students.
		Learning Environment	Teaching and learning using a technology tool is an attractive way to attract students' attention.
		Hardware and Software	The minimum hardware as you listed is suitable to used by preschool students.
		ELM	ELM is suitable to apply with ARMS prototype. Based on the four stages in this model, each student needs to complete their exercise based on their understanding.

Based on the experts' feedback, it is obvious that the elements of R-IARC, which are User, Syllabus, Learning Environment, and Hardware and Software, are required in the development of ARMS. As for the ELM elements, the experts found that Concrete Experience (CE), Reflect Observation (RO), Abstract Conceptualization (AC), and Active Experimentation (AE) are very suitable in assisting the students' cognitive development process.

As the conclusion, the identified components are sufficient to be used for developing the AR technology teaching and learning aids for Basic Science subject, specifically for the Human Body topic. Moreover, the results also revealed that the experts supported ELM as suitable and able to enhance the students' understanding in the Basic Science subject.

6.2.2 AR Expert Review

The purpose of this process is to ensure that the Elements of AR is able to implement ARMS in the preschool environment. This process appointed two individuals in the AR domain. They are officers from HitLab, New Zealand, and a lecturer from Universiti Utara Malaysia (UUM). The reviews were conducted on the technical aspects of the requirement model. Both of the experts have strong background in developing the AR technology. This process was done via email and face-to-face approach.

The review of requirement model of ARMS comprises three stages as follows:

1. Identify the requirement model of ARMS: Once the process has been done to initialize the expert AR and briefing session to explain about the requirement of ARMS, they are required to ensure the elements are correct based on their experienced in AR technology.

2. Review the requirement model of ARMS: The AR experts were asked to comment on the following Elements in AR. They are required to check and verify whether the elements are specific, correct, and workable.

3. Verification the requirement model: The verification was based on their experience in the AR technology. The experts are able to modify the

elements to suit the requirement model if the components, elements, or module are not suitable to be implemented in the preschool environment.

The feedback given regarding the requirement model and its contents was positive and taken into consideration in finalizing the ARMS model. They provided valuable comments and suggestions to improve the proposed model as shown in Table 6.3.

Table 6.3: AR Experts Feedbacks

Respondents	Aspects	Comments and Suggestion
Respondents 1	General Comments	You need to provide more descriptions of your system or intended system beyond the diagram of the system.
	Components of AR	You need to dig out the AR parts. You will find lots of related work about AR, especially considering that we can describe them in layers and in more modules.
Respondents 2	General Comments	Provide a web-based AR to ensure robustness of the application.
	Components of AR	Tracking and registration, and display technology are required as a processing part. Toolkit needs to develop the prototype.

6.3 The Validation of ARMS Prototype

This section discusses the evaluation of ARMS prototype. The evaluation was conducted to examine the potential of ARMS prototype in improving the cognitive thinking of students in learning the muscular system and their acceptance of this technology. The respondents for this prototype can be categorized into two categories, which are i) expert teachers and ii) preschool students. The evaluation process for the experimental group was mentioned in Section 3.6.4.

6.3.1 Validation Focusing on the Feedback from Teachers

An experimental study was conducted in four government preschools in Kubang Pasu, Kedah. This evaluation involved four expert teachers. Based on the teachers' feedback, they agreed that AR is effective and practicable to be implemented in preschools as a support tool in the teaching and learning for the Basic Science subject.

6.3.1.1 Reliability Analysis

Reliability analysis is used to measure that the test scores of the variables construction are consistent. There are several techniques to checking reliability such as test-retest reliability, split half, and Cronbach's alpha. However, this study applied Cronbach's alpha to test the internal consistency. According to George and Mallery (2003), there are six categories of internal consistency using Cronbach's alpha as depicted in Table 6.4:

Table 6.4: The Acceptable Rules of Cronbach's Alpha

Cronbach's alpha	**Internal consistency**
$\alpha \geq 0.90$	Excellent
$0.90 > \alpha \geq 0.80$	Good
$0.80 > \alpha \geq 0.70$	Acceptable
$0.70 > \alpha \geq 0.60$	Questionable
$0.60 > \alpha \geq 0.50$	Poor
$0.50 > \alpha$	Unacceptable

Based on Table 6.3, the range of score that should be obtained is .7 and above, as acceptable reliability (SPSS FAQ, n.d). Table 6.5 presents the results obtained from the Cronbach's alpha analysis based on the quality of acceptance involved the visualization, effectiveness, and efficiency. The sample to test the reliability involved 20 respondents in this area.

Table 6.5: Statistical Results for Reliability Analysis on Quality of Acceptance

Indicators	**Attribute**	**Cronbach's alpha**	**Summarize**
Visualization	Marker	Cronbach's Alpha: .969; N of Items: 2	Overall alpha (α) is .969, which is very high and indicates strong internal consistency among the two Task Value items.
	Video/3D Object	Cronbach's Alpha: .966; N of Items: 3	Overall α is .966, which is very high and indicates strong internal consistency among the three Task Value items.
	Comprehensive Note	Cronbach's Alpha: .984; N of Items: 7	Overall α is .984, which is very high and indicates strong internal consistency among the seven Task Value items.
Effectiveness	Usefulness	Cronbach's Alpha: .947; N of Items: 3	Overall α is .947, which is very high and indicates strong internal consistency among the three Task Value items.

	Ease of Use	Cronbach's Alpha: .832 N of Items: 2	Overall α is .832, which is relatively high internal consistency among the two Task Value items.
	Ease of Learning	Cronbach's Alpha: .971 N of Items: 3	Overall α is .971, which is very high and indicates strong internal consistency among the three Task Value items.
	Satisfactions	Cronbach's Alpha: .935 N of Items: 3	Overall α is .935, which is very high and indicates strong internal consistency among the three Task Value items.
	Learning of Experience	Cronbach's Alpha: .959 N of Items: 3	Overall α is .959, which is very high and indicates strong internal consistency among the three Task Value items.
Efficiency	Reusable	Cronbach's Alpha: .865 N of Items: 3	Overall α is .865, which is relatively high internal consistency among the three Task Value items.

As the result in Table 6.5 shows, the overall is $\alpha \geq .8$, which is very high and indicates strong internal consistency among the quality of acceptance.

6.3.1.2 Data Analysis

A structured questionnaire with 68 questions was used in this study. The results of the survey were analyzed by using statistical methods, which are mean and standard deviation. Table 6.6 shows the level of internal scales applied in this study as mentioned in Chapter 3.

Table 6.6: The Level of Interval Scale

Level	**Description**
1.00 – 1.99	Strongly disagree
2.00 – 2.99	Disagree
3.00 – 3.99	Neither
4.00 – 4.99	Agree
5.00 – 5.99	Strongly agree

The questionnaire was divided into six sections to measure the quality of acceptance, which includes:

1. Visualization

   This section seeks information related to the marker, video/3D, and comprehensive notes provided by ARMS. The aim of visualization in this study is to improve the communication in teaching and learning for muscular system. Two characteristics emphasized in this visualization are i) simple and clear to understand, ii) and help to improve the interaction between teachers and students.

   Table 6.7 shows the attributes of marker, which has two (2) items. Overall, the result represents the mean value of the score for the marker is 4.00 until

4.25. The results show that respondents agreed that the markers used in this study are acceptable and effective in terms of the display and size.

Table 6.7: Marker

Attributes	Expert Teachers	
	Mean	Std. dev
Display text and graphics provided is easily understood	4.25	0.500
Size markers are provided are appropriate and easily detected	4.0000	0.00000

Table 6.8 shows the three attributes of video and 3D objects. The high of mean value is 4.50 and the small mean value is 4.25. The results show that the respondents agreed that the use of 3D objects in teaching and learning are interesting compared to the traditional ways. However, the quality of video affected the results. This is caused by the low cost webcamera used in this study.

Table 6.8: Video and 3D Objects

Attributes	Expert Teachers	
	Mean	Std. Dev
3D objects in this video are clear and easy to understand in accordance with the information.	4.5000	0.57735
3D model is able to provide additional information to students.	4.5000	0.57735
The quality of video is good	4.2500	0.50000

Table 6.9 presents seven attributes of comprehensive notes. Overall, the experts' results represent that the mean value of the score for the comprehensive notes is between 3.50 until 4.25. The low value of mean

refers to the text size. As conclusion, respondents agreed that comprehensive notes are acceptable to be applied for this study.

Table 6.9: Comprehensive Notes

Attributes	**Expert Teachers**	
	Mean	Std. dev
Provide appropriate information for preschools	4.2500	0.25000
The comprehensive note content is easily understood	4.0000	0.00000
Layout content is clear	4.0000	0.00000
Use suitable graphics to attract childrens' attention	4.0000	0.00000
Text and graphics affect the learning system	4.2500	0.50000
Use suitable font sizes for comprehensive notes	3.5000	1.00000
The text colour is easy to read	4.0000	0.00000

2. Effectiveness

This section covers five elements in effectiveness, namely usefulness, ease of use, ease of learning, satisfaction, and learning of experience. Its purpose is to ensure whether the ARMS is effective as a support tool to be implemented in the preschool environment.

Table 6.10 shows three attributes of usefulness. Overall, the results from respondents represents showed that the mean value of each attribute is 4.50. Based on the results, the respondents agreed that AR is effective and practicable as a support tool in the teaching and learning for Basic Science.

Table 6.10: Usefulness

Attributes	Expert Teachers	
	Mean	Std. dev
The AR technology assist me more effective in teaching and learning process	4.5000	0.57735
AR technology make me more interested in teaching and learning process	4.5000	0.57735
AR technology is very useful	4.5000	0.57735

Table 6.11 shows the two attributes in ease of use. Overall, the results displayed that the mean value among experts is between 4.25 until 4.50. From the table, the respondents agreed that AR technology is user-friendly and suitable to implement in the preschool classroom.

Table 6.11: Ease of Use

Attributes	Expert Teachers	
	Mean	Std. dev
AR technology is easy to use.	4.2500	0.50000
AR technology is flexible	4.5000	0.57735

Table 6.12 shows the two attributes in ease of learning. Overall, the results showed that the mean value among experts is between 4.25 until 4.50. The results also indicated that the respondents agreed that learning could be improved through AR technology.

Table 6.12: Ease of Learning

Attributes	Expert Teachers	
	Mean	**Std. dev**
I learned to use it quickly	4.5000	0.57735
I easily remember how to use this AR technology	4.2500	0.50000

Table 6.13 shows the three attributes in satisfactions. Overall, the experts' results showed that the mean value of the score for the marker is 4.50. Based on the results, respondents agreed that they are satisfied with the use of AR as a support tool in the teaching and learning of Basic Science subject.

Table 6.13: Satisfactions

Attributes	**Expert Teachers**	
	Mean	Std. Dev
I would recommend this application to a friends	4.5000	5.7735
It is fun to use	4.5000	0.57735
I am satisfied with it	4.5000	5.7735

Table 6.14 shows the three attributes in learning of experience. Overall, the experts' results displayed that the mean value of the score is 4.50. However, it can be concluded that the respondents preferred to use AR in their teaching and learning sessions to attract the students' attention in the Basic Science subject.

Table 6.14: Learning of Experience

Attributes	**Expert Teachers**	
	Mean	Std. dev
I would use this application again as a support tool in the teaching and learning process	4.5000	5.7735
Support tools such as this is able to attract students' attention compared to the usual support tools	4.5000	0.57735
This technology is being introduced to the preschool students	4.5000	5.7735

3. Efficiency

This section is to measure the ability in reusing the ARMS for other subjects, and its practicality for other situations. There is one element in efficiency which is reusable as depicted in Table 6.15. Based on the acquired results, AR technology is suitable for implementation in other subjects and practicable at home.

Table 6.15: Reusable

Attributes	**Expert Teachers**	
	Mean	Std. dev
Teaching methods are suitable for use in other subjects	4.2500	0.50000
Content of this topic can be used in different learning situations (eg self-learning or collaborative)	4.5000	0.57735
Content of this topic is suitable for a wide variety of situation, time and place (eg at school, at home, at cybercafe)	4.2500	0.50000

4. Entertainment and fun

This section covers the entertainment and fun. The entertainment refers to the ability of ARMS in attracting students' attention. Besides, the element of fun depends on the users' feelings to use ARMS as their support tool. There are two elements in this section, which are entertainment and fun. The detailed results are as follows.

Table 6.16 shows the four attributes in entertainment. Overall, the results showed that the mean value of the score is 4.50. From the results, the respondents agreed that AR technology is able to make teaching and learning interesting to attract students' attention.

Table 6.16: Entertaining

Attributes	Expert Teachers	
	Mean	Std. dev
ARMS attracts and captures my attention	4.5000	0.57735
ARMS arouses my teaching or learning emotion through AR technology	4.5000	0.57735
ARMS presents the information in interesting ways	4.5000	0.57735
The use of ARMS is entertaining for the students to understand the information delivered	4.5000	0.57735

Table 6.17 shows the five attributes in entertainment. Overall, the results showed that the mean value between 4.50 until 4.75. From the results, the respondents agreed on the fun and comfortable ARMS application as their support tool in the Basic Science subject, specifically for the learning of muscular system.

Table 6.17: Fun

Attributes	Expert Teachers	
	Mean	Std. dev
ARMS makes my students laugh	4.7500	0.50000
I was happy to use ARMS as my support tool	4.5000	0.57735
I was excited when teaching or learning with ARMS	4.5000	4.5000
Teaching or learning using ARMS is enjoyable	4.7500	0.50000
I feel comfortable to teach or learn with ARMS	4.7500	0.50000

5. ELM

This section focuses on the four stages of learning cycle, which consists of abstract conceptualization (AC), concrete experience (CE), active experimentation AE), and reflect observation (RO). The purpose of ELM in this study is to recognize the students' cognitive skills. The result of ELM was evaluated after the evaluation phase based on the observation during the exercises sessions. Therefore, this study implemented ELM process based on the following sequence:

a. AC: Listening to explanation on the topic by their teacher.
b. CE: Going step-by-step through the comprehensive notes given to students.
c. AE: Practicing using ARMS prototype.
d. RO: Testing students using ARMS exercises.

This result has divided into four (4) part analysis based on the four-stage of ELM as below:

i. AC: According to Table 6.18, students were able to understand the concept of muscular system based on the explanation by their teacher. Students tried to arrange and organize the muscular system information systematically in concepts and ideas.

Table 6.18: Abstract Conceptualization

Attributes	**Expert Teacher**	
	Mean	Std. Dev
Understanding the concept and the principal	4.2500	0.50000
Students trying to organize and arrange information logically	4.5000	0.57735
Students trying to organize and arrange information in the form of the concepts systematically	4.5000	0.57735
Students trying to organize and arrange information in the form of the theory systematically	4.5000	0.57735
Students trying to organize and arrange information in the form of the idea systematically	4.2500	0.50000

ii. CE: Based on Table 6.19, students participate fully in active experience with an open mind, and give good feedback to them in lessons. In addition, the experts stated and agreed that students acquired the muscular system information by direct experience when they were involved actively in the learning environment. This has been proven when there were several misunderstanding of the muscular system before the study was conducted. Therefore, the direct experience is required to gain the understanding and create or change their minds to receive the right information.

Table 6.19: Concrete Experience

Attributes	**Expert Teachers**	
	Mean	Std. Dev
Students participate fully in new experiences actively	4.7500	0.50000
Students participate fully in new experiences with an open mind	4.5000	0.57735
Students acquire information by direct experience	4.7500	0.5000

iii. AE: Students participated directly and used ARMS. After using the ARMS, they were clear about the muscular system objects. In addition, ARMS was able to attract students' attention in lessons. Therefore, it was more helpful for teachers to deliver the complex topics in easy and entertaining way for preschool students as shown in Table 6.20.

Table 6.20: Active Experimentation

Attributes	**Expert Teacher**	
	Mean	Std. Dev
Students are directly involved in the environment in finding solutions for problems (experimental)	4.0000	0.81650
Students are able to complete the exercise provided	4.7500	0.50000

iv. RO: Results in Table 6.21 showed that the learner must possess decision-making and problem solving skills in order to use new ideas gained from the experience. This study provided ARMS exercises for preschool students. They need to complete the task based on their understanding about the muscular system. Based on the exercises provided, students gain the potential benefits of skills, which is the listening skill and attentive in the new experience with ARMS as a support tool.

Table 6.21: Reflect Observation

Attributes	**Expert Teacher**	
	Mean	Std. Dev
Students become observers using listening skills in a new experience	3.5000	1.73205
Students become observers to observe skills in new experience	3.7500	1.25831
Students become observers with an awareness of changes in skill in the new experience	3.7500	1.25831

6.3.2 Validation Focusing on the Feedback from Students

This section discusses on the unstructured interview results with the preschool students. The average number of student per class was 22 and they were divided into five groups during the experimental group sessions. The age range of the students was five to six years old. The interviews focused on the familiarity, visualization, effectiveness, and entertaining and fun. This study lists five comments frequently used by respondents.

6.3.2.1 Familiarity of AR Application in Learning Environment

Most respondents said they did not know about AR. According to them, this ~~is~~ was their first experience using AR application in lessons. After the demonstration and evaluation process, the respondents were able to understand what AR is and how it functions. The respondents also gave good feedback to use AR in the learning environment as follows:

- Comments 1: "Magic! I like to use this kind compared to using CD"
- Comments 2: "That's cool! This is my first time to see the tool like this one"
- Comments 3: "Awesome! I like to tell my parents about this kind technology"
- Comments 4: "I am impressed! This tool is easy to use and ~~to~~ understand"
- Comments 5: "I am interested to use this tool again"

6.3.2.2 Visualization Perception of ARMS in Learning Muscular System

The visualization information provides a good overview consisting of marker, 3D and comprehensive notes. Based on the interviews, the respondents were more comfortable with the size of marker provided in terms of the display and size. In addition, the respondents were interested using 3D objects compared to using the conservative ways. The respondents were more attracted to the comprehensive notes because the notes were more interactive compared to the standard textbooks. The comments from respondents are:

- Comments 1: “The picture of the marker is clear and easy to recognize the image of heart, stomach, and skeleton”
- Comments 2: “I like the heart, stomach, and skeleton cartoon in this kind”
- Comments 3: “This is a magic paper. The standard textbook cannot do like the paper”
- Comments 4: “I am excited to use this paper. It can display the cartoon”
- Comments 5: “I like to play with the marker, and this paper. Today, I was able to recognize the appearance of the heart, stomach, and skeleton”

6.3.2.3 Effectiveness Perception of ARMS in Learning Muscular System

Based on the interviews, ARMS technology make them interested in learning the muscular system. According to the respondents, the ARMS is easy to use and make them attentive in lessons. The respondents agreed that learning could be improved by implementing the AR technology in the classroom.

- Comments 1: “It easy to use”
- Comments 2: “I learned to use it quickly”
- Comments 3: “Now, I know and remember the muscular system”
- Comments 4: “This tool is attract my attention”
- Comments 5: “I like to use the tool again”

6.3.2.4 Entertaining and Fun Perception of ARMS in Learning Muscular System

The ARMS provides good impact for the respondents to learn the muscular system. According to the respondents, ARMS was able to attract their attention and make them interested to learn the muscular system because the way the information was presented.

- Comments 1: “This is interesting learning using this tool”
- Comments 2: “I was so happy using this tool”
- Comments 3: “Teacher, can we use this tool again?”
- Comments 4: “I like the way of animation”
- Comments 5: “I was excited to do the exercise”

6.4 Conclusion

The main focus of this chapter is to review and validate the requirement of ARMS model as proposed in this study. The science teachers covered the two components consisting of Requirements to Implements AR in Classroom (R-IARC), and Experiential Learning Model (ELM). R-IARC includes four modules in Elements of Science Implementation, which are user, syllabus, learning environment, and hardware and software. The AR experts covered the Elements of AR in R-IARC components. The elements consist of three modules; tracking and registration, display technology, and toolkit.

Based on the evaluation results, it was found that ARMS is highly effective to be implemented in the Basic Science subject. Apart from that, it was also proven that the integration of AR technology in traditional teaching creates an enjoyable learning environment. As a conclusion, students are able to understand the discussion topic using the ARMS. In addition, the ARMS is able to assist the learning process, enhance the learning environment of science, improved the students' abilities, and encourage students to think critically and creatively. The next chapter will discuss the conclusion of this study and recommendations for future research.

CHAPTER SEVEN
CONCLUSION AND RECOMMENDATION

7.1 Chapter Overview

This study aimed to develop the requirement model for Augmented Reality for Learning Muscular System (ARMS). Hence, this study was conducted based on the three research questions:

1. What are the requirements used to be considered for AR implementation in learning environment?
2. How can the development of AR application be simplified?
3. What are the quality criteria needed to be considered for developing and effective learning support tool for preschool students?

Therefore, this chapter describes the solutions proposed for each research questions. In addition, this chapter also provides the summaries, discussions, and research contributions. The chapter ends with the discussion of future work and conclusion of the study.

7.2 Research Question

This research has achieved to answer the following questions that were addressed in this study:

7.2.1 What Are the Requirements Used as Consideration for AR Implementation in the Learning Environment?

In answering the question, few activities were conducted and discussed in detail in Chapter 5. The main purpose of this activity is to identify the AR components involved in developing the AR which are currently practiced by AR developers. The activities include content analysis of the literature (Chapter 2), components of AR system (Section 2.3.1), learning theories (Section 2.5), the current practice and teaching of science subject (Section 2.6.3), ALE (2.8), and document review of primary school curriculum standard (Section 4.2.3).

Consequently, these activities have identified the main components required in constructing the requirements of ARMS model. Additionally, the proposed requirement model comprises of the components, modules, elements, flows, activities and deliverable for development of ARMS application. The list of activities is as follows:

1. Components: The main part that contributes to each activity phase.
2. Modules: The self-contain in each main component.
3. Elements: A method which operates based on the characteristics.
4. Flows: The way of progress from one phase or activity to another. Activities referred to specific steps suggested to be conducted during the ARMS development. The output produced at each ~~phases~~ was discussed in Chapter 5.

Furthermore, all these models were combined to construct the ARMS model. These components were constructed based on the component-based software framework technique, specifically to the AR system. The ARMS model proposed the following three main components:

1. Requirements to Implement AR in Classroom (R-IARC)
2. High-Level Prototyping (HLP)
3. Experiential Learning Model (ELM)

7.2.2 How Can the Development of AR Application Be Simplified?

This study considered the three aspects consisting of technological tool, safety, and cost as suggested by ALE (Section 2.8). The three hardware involved in this study were a web camera, laptop, and a marker as discussed in Chapter 5 (Section 5.3.1.1):

1. Web camera: The web camera used in this study is1300K pixels, sensor type CMOS 1300k, video capture resolutions up to 640 x 480, 24 digit of colour, and video frame rate up to 38 frames.

2. Laptop: The specification of this laptop is 3GB RAM, 80GB HDD. The processor is Intel Core Duo Processor T2300E (1.66GHz, 66 MHz FSB, 2 MB L2 cache). The operating system installed is Microsoft Windows XP version 2002.

3. Marker: The marker was designed by using a good quality paper for durability. It used black and white colours in 2.45” x 3.11”.

The software used in this study are ARToolKit, Microsoft Visual Studio, and 3D Studio Max 7 (3DS Max 7). The list of hardware and software to develop ARMS are shown in Figure 7.1.

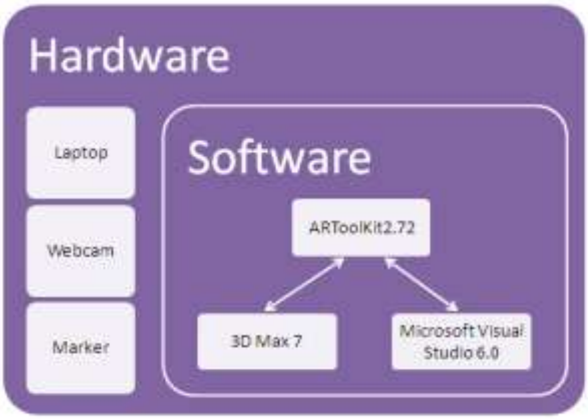


Figure 7.1: Requirements for Developing the AR Application in Basic Science Subject

7.2.3 What are the Quality Criteria Needed to be Considered for Developing an Effective Learning Support Tool for Preschool Students?

In an effort to get a proper review of the components proposed, the requirement model was reviewed by two domain experts. The four Basic Science teachers and two experts in AR were selected. The selected experts in this study required strong background experience in the related area. The four experts in Basic Science subject were the Basic Science teachers. On the other hand, the experts in AR were the researchers at the Human Interface Technology Laboratory New Zealand (HITLabNZ), University of Canterbury, New Zealand and AR Lecturer in Universiti Utara Malaysia (UUM). They are well-known in the AR research and industries.

Additionally, they were required to evaluate the requirement model of ARMS based on components, modules, and elements. The process was to ensure that the content of the requirement model matched the selected topic and appropriate for teaching and learning session with AR as a supportive tool. Consequently, the expert teachers were required to validate the Elements of Science Subject Implementation and the adoption of Experiential Learning Model (ELM). On the other hand, two AR technology experts validated the adaptation of Elements of AR. Additionally, the proposed requirement model for ARMS was well accepted by all the experts involved in this study. Based on the review conducted by the experts, the results were detailed out in Chapter 6.

Besides, the evaluation was conducted to view whether this technology could assist in the cognitive development of preschool students and their acceptance of this technology. The four qualities of acceptance criteria for ARMS prototype were applied: i) visualization, ii) effectiveness, iii) efficiency, and iv) entertaining and fun. The finalized evaluation of ARMS prototype has proved that this technology was accepted by the expert teachers and preschool students as a supportive tool in the teaching and learning of the Basic Science subject while supporting the students' cognitive development.

7.3 Objectives of the Study – Revisited

The aim of this study is to propose a requirement model for AR in Basic Science subject to support the teaching and learning sessions at preschool level. The model is developed to ensure helpfulness of ARMS development. To achieve the main aim, three specific objectives were formulated:i) to specify the AR requirements for developing a learning support tool, ii) to construct a requirement model based on the identification of the main components, and iii) to evaluate the proposed AR application based on the identified criteria.

At the end of this study, the main aim has been achieved through the completion of the three supporting objectives. The first objective was achieved by identifying the issues in science subject. The identification was made through the extensive literature and interviews.

Next, the second objective was accomplished with the identification of the three main components of the ARMS model which are i) R-IARC, ii) HLP, and iii) ELM. The identification was made through the interviews, observation, and document review. The component-based software framework was adopted to construct the ARMS model.

Finally, the third objective was achieved by performing the review and validating the model through the expert reviews. The experts for this research could be categorized into two categories of different area: Basic Science teachers and AR experts. The results concluded that the ARMS model was acceptable to be implemented in the preschool environment.

7.4 Limitation and Future Works

There are some limitations in this study. The suggestions for improvement are:

1. The experts suggested tangible AR techniques to be included in the prototype because the implementation will foster interactivity features between the

students and prototype. However, the suggestion was not implemented because it involves a lot of students. The suggestions will be implemented in the future.

2. Limited time frame, animation, interactive, and budget to get the real AR of the current practice for evaluation.
3. A lot of time and effort being spent to review documents, respondents, and feedback.
4. Limitation on the VRML. The virtual object in 3D Max is not the same after being converted into VRML format.

7.5 Conclusion

This research has produced and proposed the requirement model for supporting the teaching and learning of Basic Science subject using AR technology. The model consists of three main components, which are R-IARC, HLP, and ELM.

The R-IARC component, which is to ensure the implementation of ARMS in the classroom, can be implemented effectively by combining the two modules; Elements in Teaching & Learning Basic Science Subject, and Element of AR. In addition, the HLP is the process to apply AR in the Basic Science subject in lessons. Finally, the ELM was integrated in this study to support the teaching and learning styles.

In conclusion, based on the research findings, it indicates that the proposed requirement model for ARMS is accepted by developers and educators to be adopted as a support tool in the classroom in the future.

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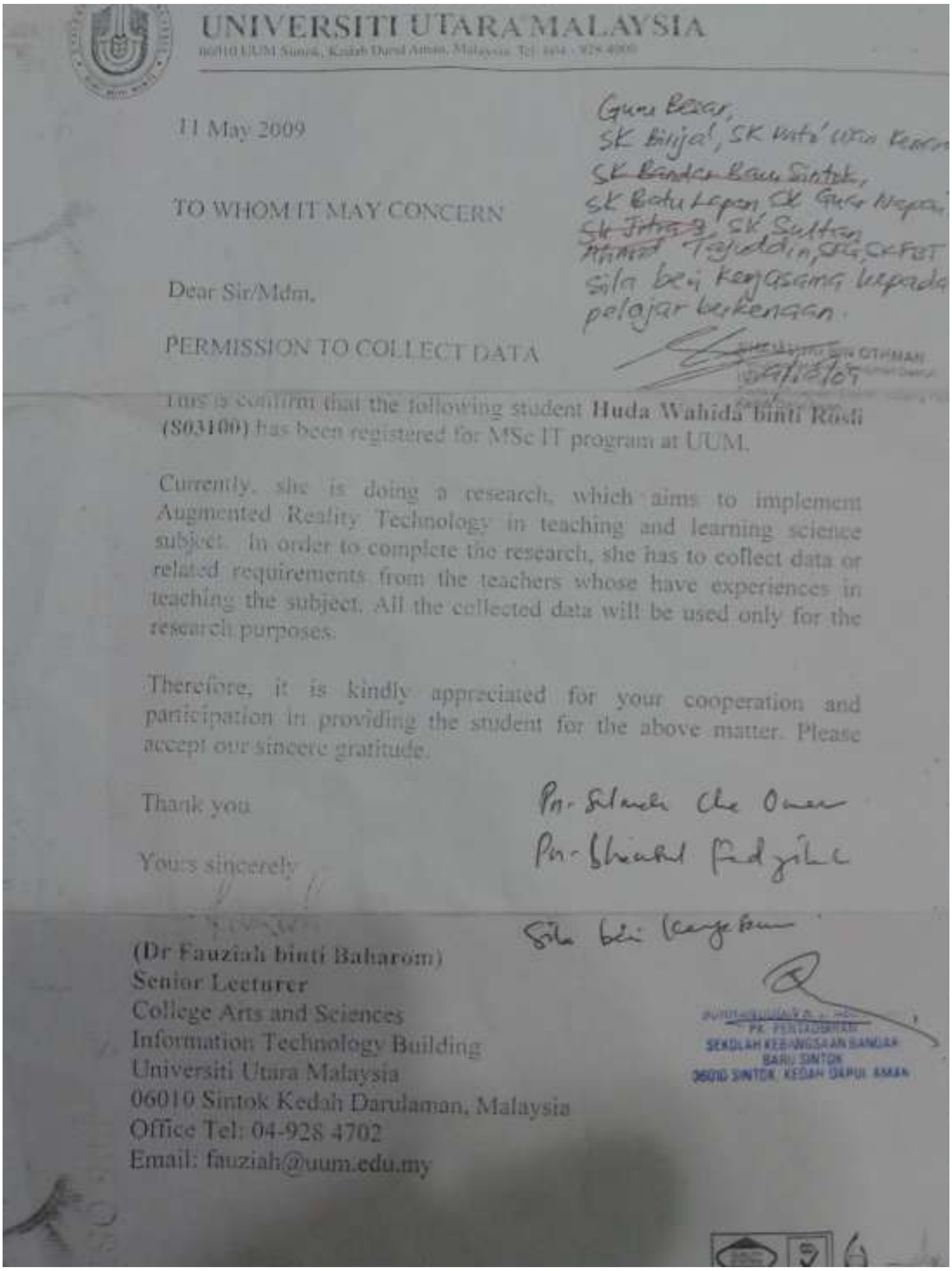
Appendix A

Letter Permission To Collect Data (District Education Officer Kubang Pasu, School Principal and Teachers)



UNIVERSITI UTARA MALAYSIA

11 May 2009

TO WHOM IT MAY CONCERN

Dear Sir/Mdm,

PERMISSION TO COLLECT DATA

This is confirm that the following student **Huda Wahida binti Rosli (803100)** has been registered for MSc IT program at UUM.

Currently, she is doing a research, which aims to implement Augmented Reality Technology in teaching and learning science subject. In order to complete the research, she has to collect data or related requirements from the teachers whose have experiences in teaching the subject. All the collected data will be used only for the research purposes.

Therefore, it is kindly appreciated for your cooperation and participation in providing the student for the above matter. Please accept our sincere gratitude.

Thank you

Yours sincerely

(Dr Fauziah binti Baharom)
Senior Lecturer
College Arts and Sciences
Information Technology Building
Universiti Utara Malaysia
06010 Sintok Kedah Darulaman, Malaysia
Office Tel: 04-928 4702
Email: fauziah@uum.edu.my

Guru Besar, SK Bijjal, SK ... SK Bandar Baru Sintok, SK Batu Lapan, ... sila beri kerjasama kepada pelajar berkenaan.

SEKOLAH KEBANGSAAN BANDAR BARU SINTOK
06010 SINTOK, KEDAH DARUL AMAN

Appendix B

List of Expert Teachers

Respondents	Schools	Year of Experience
Respondent 1	Sekolah Kebangsaan Binjal	18
Respondent 2	Sekolah Kebangsaan Guar Napai	17
Respondent 3	Sekolah Kebangsaan Wan Kemara	18
Respondent 4	Sekolah Kebangsaan Batu 8	11

Appendix C

Instrument For Expert Review (Experts Teacher)

KOLEJ SASTERA DAN SAINS

UNIVERSITI UTARA MALAYSIA

06010 SINTOK KEDAH DARUL AMAN

PENILAIAN DAN PENGESAHAN PAKAR KE ATAS MODEL KEPERLUAN ARMS (AUGMENTED REALITY FOR MUSCLE SYSTEM)

TUJUAN SOAL SELIDIK

Soal selidik ini bertujuan untuk mendapatkan maklumat serta ulusan berdasarkan kepakaran anda di dalam bidang pendidikan awal kanak-kanak. Kajian ini untuk menilai model keperluan Teknologi Realiti Tambahan (*Augmented Reality Technology*) yang dicadangkan ialah *Augmented Reality for Muscular System (ARMS)*. Model ini akan digunapakai diperingkat prasekolah dalam mata pelajaran Awal Sains. Model keperluan ini telah direka untuk memastikan ianya menyokong serta membantu dalam proses pengajaran dan pembelajaran di dalam kelas bagi subjek tersebut. Pembangunan prototaip akan dibangunkan berdasarkan model keperluan yang dicadangkan.

Justeru, kerjasama anda sebagai guru pakar diperlukan untuk penambahbaikan perlaksanaan penggunaan teknologi Realiti Tambahan dalam bidang pendidikan terutamanya untuk subjek Awal Sains. Maklum balas yang diterima dari pihak anda akan membantu dalam proses pengesahan kesemua elemen yang terlibat di dalam model keperluan ARMS yang dicadangkan.

ARAHAN

Terdapat bahagian di dalam boring ini.

1. Bahagian A: Maklumat Responden
2. Bahagian B: Elemen Utama Dalam Model Keperluan ARMS
3. Bahagian C: Elements in Teaching and Learning Basic Science Subject
4. Bahagian D: Experiential Learning Mdel

Maklumat yang anda berikan adalah sulit dan hanya digunakan di dalam kajian ini. Anda dialu-alukan untuk menghubungi saya jika terdapat sebarang pertanyaan melalui email hudawahida@yahoo.com. Terima kasih atas kerjasama yang telah diberikan.

BAHAGIAN A: MAKLUMAT RESPONDEN

1. Nama :____
2. Email :____
3. Jantina :____
4. Pekerjaan :____
5. Sekolah :____
6. Pengalaman Kerja (Tahun) : ____

BAHAGIAN B: ELEMEN UTAMA DALAM MODEL KEPERLUAN ARMS

Sila berikan pandangan serta pengalaman anda terhadap model keperluan ARMS yang dicadangkan ini dalam melaksanakan penggunaan AR sebagai alat bantu mengajar:

1. *Requirement to Implements AR in Classroom*

   Tujuan: Untuk mengenalpasti kesemua elemen dan komponen yang dicadangkan mampu untuk memastikan pelaksanaan AR sebagai P&P serta boleh diadaptasi dalam pembelajaran Awal Sains di dalam kelas untuk peringkat prasekolah.

   ____

   ____

   ____

2. *Elements in Teaching & Learning Basic Science Subject*

   Tujuan: Untuk mengenalpasti kesemua elemen yang dicadangkan di dalam kompponen ini boleh dilaksanakan dengan baik dalam P&P dengan sokongan teknologi AR bagi subjek Awal Sains.

   ____

   ____

   ____

3. Experiential Learning Model (ELM)

   Tujuan: Model ELM ini bertujuan untuk menggalakan gaya pembelajaran berasaskan eksperimen selari dengan kajian ini. Model ini digunakan untuk mengenalpasti sama ada kefahaman pelajar terhadap system otot dapat difahami dengan baik melalui penggunaan AR sebagai alat bantu mengajar.

   ____
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   ____

KOMEN/CADANGAN

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____

BAHAGIAN C: ELEMENTS IN TEACHING AND LEARNING BASIC SCIENCE SUBJECT

1. Pengguna (User):

   Tujuan: Terdapat dua sasaran kategori pengguna iaitu guru dan pelajar untuk menggunakan prototaip ARMS. Pada pandangan anda, adakah kedua-dua pengguna ini penting untuk diambil kira supaya elemen dalam perlaksanaan Sains menggunakan AR dapat dijalankan dengan baik?

   ____

   ____

   ____

2. Silibus (Syllabus)

   Tujuan: Elemen ini berfungsi sebagai garis panduan untuk memastikan pelaksanaan ARMS bersesuaian dengan tahap pembelajaran penggguna sasaran.

   ____

   ____

   ____

3. Persekitaraan Pembelajaran (Learning Environment)

   Tujuan: Adakah dengan melaksanakan AR dapat membantu dalam proses meningkatkan kualiti P&P?

   ____

   ____

   ____

4. Perkakasan dan Perisian (Hardware and Software)

   Tujuan: Adakah element perkakasan (webcam, marker, dan laptop) dan perisian (ARToolKit) sesuai untuk digunakan pada tahap pengguna sasaran?

____
____
____

KOMEN/CADANGAN

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BAHAGIAN D: EXPERIENTIAL LEARNING MODEL (ELM)

1. Pengalaman Konkrit (merasai)

   Tujuan: Pelajar melibatkan diri sepenuhnya dalam pembelajaran ARMS secara aktif, berfikiran terbuka, dan mudah beradaptasi.

   ____
   ____
   ____

2. Pemerhatian Refleksi (memerhati)

   Tujuan: Pelajar menjadi pemerhati dengan menggunakan kemahiran seperti mendengar, memerhati, dan sedar perubahan yang berlaku dalam pembelajaran ARMS.

   ____
   ____
   ____

3. Konseptual Abstrak (berfikir)

   Tujuan: Pelajar perlu berusaha untuk mengatur dan menyusun maklumat secara sistematik dan logik dalam bentuk konsep, teori, dan idea melalui latihan yang diberikan.

   ____

   ____

   ____

4. Eksperimentasi Aktif (melakukan)

   Tujuan: Pelajar terlibat secara langsung dengan persekitaran dalam pembelajaran Sains untuk mencari penyelesaian dalam masalah yang dihadapi dengan menggunakan ARMS.

   ____

   ____

   ____

KOMEN/CADANGAN

____

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____

____

TERIMA KASIH

Appendix D

Instruments For Experts Review (AR)

KOLEJ SASTERA DAN SAINS
UNIVERSITI UTARA MALAYSIA
06010 SINTOK KEDAH DARUL AMAN

EXPERT REVIEW ON REQUIREMENT MODEL FOR AUGMENTED REALITY FOR MUSCLE SYSTEM (ARMS)

The purpose of the survey

The survey aims at getting input and reviews from people who have experience in AR domain. This study is seeking your expertise to evaluate the proposed model. This is a requirement model to implement the Augmented Reality for Muscular System (ARMS) topic for public preschools in Malaysia. The requirement model was designed to ensure that it supports teaching and learning in the classroom environment for Basic Science (BS) subject. The development of the prototype will be based on the proposed requirement model. Please provide your recommendations as an AR Expert for further improvements to implement AR in education area.

The feedbacks received would be much helpful in validating the model that represents the component of requirement model of ARMS.

Instruction

There are two sections in this form. **Section A** is background of respondents. The second sections, **Section B** consists of the component of requirement model for Augmented Reality for Muscular System (ARMS). This section is represents the module of Requirement to Implement AR in Classroom (R-IARC).

The information supplied will be treated as confidential and will be used for research purposes which may be reported anonymously in academic publication. Please feel free to contact me by email hudawahida@yahoo.com.

Thank you for your time.

SECTION A: BACKGROUND OF RESPONDENTS

1. Name : ________________________________
2. Email : ________________________________
3. Gender : ________________________________
4. Occupation : ________________________________
5. Working Field : ________________________________
6. Experience in AR (Year) : ________________________________

SECTION B: COMPONENTS OF REQUIREMENT MODEL FOR ARMS

Based on your perceptions and understanding of proposed requirement model of ARMS, please comments:

1. Requirement to Implement AR in Classroom

   Purpose: The elements was designed to ensure that the element of AR support teaching and learning in the classroom environment for Basic Science subject.

   a. Are the two modules which are i) Elements of BS Implementation, and ii) Elements of AR in this component enough to ensure the implementation of AR support teaching and learning session?

      ____

      ____

   b. Are the two modules adaptable in learning Basic Science in classroom for pre-school?

      ____

      ____

   c. All the concepts and components included are strictly necessary?

      ____

      ____

2. Elements of AR

Purpose: The purpose is to ensure that the elements sufficient to develop AR objects to introduce the muscular system topic for preschool children.

a. Are the elements (*tracking & registration, display technology, and authoring*) in this module is suffice to develop AR objects to introduce the muscular system topic for preschool children?

____

____

b. Are the tracking & registration required when this study only using a webcam?

____

____

c. This study is only using a webcam as the display technology. Based on your experience, are there any problems using the webcam?

____

____

d. The ARToolKit is compatible with ARMS prototype?

____

____

General Comments/Recommendation:

____

____

____

THANK YOU

Appendix E

Questionnaire

SOAL SELIDIK PENGGUNAAN APLIKASI ARMS

KOLEJ SASTERA DAN SAINS

UNIVERSITI UTARA MALAYSIA

MAKLUMAN KEPADA RESPONDEN

1. Tujuan soal selidik ini adalah untuk mengenalpasti tahap penerimaan dalam aplikasi Teknologi Realiti Tambahan (*Augmented Reality Technology*) dalam bidang pendidikan di peringkat prasekolah.
2. Jawapan yang **ikhlas** dari tuan/puan amat diperlukan untuk mendapatkan hasil kajian yang tepat.
3. Segala maklumat yang tuan/puan berikan ini adalah untuk kajian semata-mata dan akan **dirahsiakan**.
4. Sila **lengkapkan semua bahagian**.
    - Bahagian A: Visualization
    - Bahagian B: Keberkesanan
    - Bahagian C: Kecekapan
    - Bahagian D: Kebolehgunaan
    - Bahagian E: Menghiburkan dan Menyeronokkan
    - Bahagian F: Model Pembelajaran Pengalaman (*Experiential Learning Model*)
5. Kerjasama yang tuan/puan berikan amat dihargai dan didahului dengan ucapan ribuan terima kasih.

Nama Penyelidik: Huda Wahida Rosli

hudawahida@yahoo.com

MAKLUMAT	
Nama	
Alamat sekolah	
Nombor Telefon	
E-mail	
Pengalaman mengajar (Tahun)	
Matapelajar	Awal Sains
Jumlah pelajar di dalam kelas	

Alat Bantu Mengajar (ABM)	
ABM yang digunakan ketika mengajar Awal Sains	☐ Manual (Buku teks) ☐ Perisian komputer ☐ Buku Latihan ☐ Lain-lain: __________ __________ __________
Rumusan mengenai penggunaan teknologi AR ini di dalam pengajaran anda	

Sila tandakan √ pada pilihan anda:

1	2	3	4	5	Contoh				
Tidak bersetuju	Kurang Setuju	Tidak pasti	Setuju	Sangat Setuju	**1**	**2**	**3**	**4**	**5**
									√

1	2	3	4	5
Tidak bersetuju	Kurang Setuju	Tidak pasti	Setuju	Sangat Setuju

BAHAGIAN A: VISUALIZATION

Marker		**1**	**2**	**3**	**4**	**5**
1	Paparan teks dan grafik yang disediakan boleh difahami dengan mudah					
2	Saiz marker yang disediakan sesuai dan mudah dikesan					
Video/3D objek		**1**	**2**	**3**	**4**	**5**
1	Objek 3D dalam video jelas dan mudah difahami selaras dengan maklumatnya					
2	3D model mampu untuk memberi penambahan serta kelainan maklumat yang berguna kepada para pelajar					
3	Kualiti video sangat baik					
Nota Ringkas		**1**	**2**	**3**	**4**	**5**
1	Maklumat yang disediakan bersesuai di peringkat prasekolah					
2	Kandungan nota ringkas mudah difahami					
3	Rekaletak kandungan jelas					
4	Penggunaan grafik yang sesuai untuk menarik minat kanak-kanak					
5	Teks dan grafik memberi kesan kepada sistem pembelajaran					
6	Penggunaan saiz teks yang sesuai					
7	Penggunaan warna pada teks mudah untuk dibaca					
8	Paparan teks dan grafik tidak meletihkan mata					

BAHAGIAN B: KEBERKESANAN

		1	2	3	4	5
Kegunaan (Usefulness)						
1	Teknologi AR ini membantu saya lebih efektif semasa proses P&P					
2	Teknologi AR ini menjadikan saya lebih meminati proses P&P					
3	Teknologi AR ini sangat berguna					
Mudah Digunakan (Ease of Use)		**1**	**2**	**3**	**4**	**5**
1	Teknologi AR ini sangat mudah digunakan					
2	Teknologi AR ini mesra pengguna					
3	Teknologi AR ini sangat fleksibel					
Mudah Dipelajari (Ease of Learning)		**1**	**2**	**3**	**4**	**5**
1	Saya dapat mempelajari penggunaanya dengan cepat					
2	Saya mudah mengingati cara penggunaan teknologi AR ini					
3	Sangat mudah mempelajari penggunaanya					
Kepuasan (Satisfactions)		**1**	**2**	**3**	**4**	**5**
1	Saya akan mencadangkan aplikasi seperti ini kepada rakan-rakan saya					
2	Teknologi AR seperti ini sangat menyeronokkan					
3	Saya berpuas hati dengan Teknologi AR seperti ini					
Pengalaman Belajar (Learning of Experience)		**1**	**2**	**3**	**4**	**5**
1	Saya akan menggunakan aplikasi seperti ini lagi					
2	ABM seperti ini dapat menarik minat para pelajar selain dari ABM sedia ada					
3	Teknologi seperti ini sesuai diperkenalkan kepada para pelajar prasekolah					

BAHAGIAN C: KECEKAPAN

Guna semula (Reusable)		**1**	**2**	**3**	**4**	**5**
1	Kaedah pengajaran ini sesuai untuk digunakan dalam mata pelajaran yang lain					
2	Kandungan dalam topik ini sesuai digunakan dalam pelbagai situasi pembelajaran (contohnya: pembelajaran kendiri atau kolaboratif)					
3	Kandungan dalam topik ini sesuai digunakan dalam pelbagai situasi masa dan tempat (contohnya di sekolah, di rumah, di kafe siber)					

BAHAGIAN D: KEBOLEHGUNAAN

Pengalaman Pengguna dan Penerimaan (User Experienced and Acceptance)		**1**	**2**	**3**	**4**	**5**
1	Teknologi AR ini mudah difahami					
3	Saya rasa sangat terkawal menggunakan teknologi AR ini					
4	Saya yakin menggunakan teknologi AR ini					
5	Kualiti bahan memenuhi keperluan pengajaran saya					
6	Saya rasa janggal menggunakan teknologi AR seperti ini					
7	Saya berasa tidak selesa menggunakan aplikasi ini (mual/pening)					
8	Kawalan kelas tidak terjejas akibat penggunaan AR di dalam kelas					
Pedagogi (Pedagogical)		**1**	**2**	**3**	**4**	**5**
1	Saya dapat menyampaikan pelajaran dengan mudah dan berkesan					
2	Maklumat yang diberikan sesuai digunakan diperingkat prasekolah					
Rekabentuk Aplikasi (Application Design)		**1**	**2**	**3**	**4**	**5**
1	Keseluruhan objek di dalam ARMS ini boleh digunakan dengan berkesan.					
2	Keseluruhan objek di dalam ARMS ini mudah diingati					
3	Saya sangat berpuas hati dengan keseluruhan kandungan ARMS ini					

BAHAGIAN E: MENGHIBURKAN DAN MENYERONOKKAN

Menghiburkan		**1**	**2**	**3**	**4**	**5**
1	ARMS menarik perhatian saya					
2	ARMS membangkitkan emosi pengajaran saya melalui pendekatan Teknologi Realiti Tambahan (AR)					
3	ARMS mempersembahkan maklumat dengan cara yang menarik					
4	ARMS menggalakan pembelajaran dari pengalaman					
5	Cara penggunaan ARMS dapat menghiburkan para pelajar untuk memahami maklumat yang hendak disampaikan					
Menyeronokkan		**1**	**2**	**3**	**4**	**5**
1	ARMS membuatkan para pelajar saya ceria					
2	Kandungan di dalam ARMS mengandungi *humor* yang tidak dirancang					
3	Saya rasa gembira menggunakan ARMS sebagai ABM saya					
4	Saya sangat teruja mengajar dengan menggunakan ARMS					
5	Pengajaran menggunakan ARMS sangat menyeronokkan					
6	Saya rasa selesa mengajar dengan menggunakan ARMS					

BAHAGIAN F: MODEL PEMBELAJARAN PENGALAMAN

Pengalaman Konkrit (Concrete Experience)		**1**	**2**	**3**	**4**	**5**
1	Pelajar melibatkan diri sepenuhnya dalam pengalaman baru secara aktif.					
2	Pelajar melibatkan diri sepenuhnya dalam pengalaman baru dengan fikiran terbuka					
3	Pelajar memperoleh maklumat dengan pengalaman secara langsung					
Konseptual Abstrak (Abstract Conceptualization)						
1	Pemahaman konsep dan principal					
2	Pelajar berusaha untuk mengatur dan menyusun maklumat secara sistematik dan dalam bentuk konsep, teori, dan idea.					
3	Pelajar berusaha untuk mengatur dan menyusun maklumat					

	secara logik					
4	Pelajar berusaha memahami konsep					
5	Pelajar berusah memahami teori					
6	Pelajar berusaha memahami idea					

Pemerhatian Reflektif (Reflect Observation)						
1	Pelajar menjadi pemerhati dengan menggunakan kemahiran seperti mendengar dalam pengalaman baru					
2	Pelajar menjadi pemerhati dengan menggunakan kemahiran seperti memerhati dalam pengalaman baru					
3	Pelajar menjadi pemerhati dengan menggunakan kemahiran seperti sedar perubahan yang berlaku dalam pengalaman baru					
Eksperimentasi Aktif (Active Experimentation)						
1	Pelajar terlibat secara langsung dengan persekitaraan dalam mencari penyelesaian dalam masalah yang dihadapi (eksperimen)					
2	Pelajar mampu menyelesaikan latihan yang diberikan					

Lain-lain, sila nyatakan:

____

____

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____

____

TERIMA KASIH

Appendix F

Unstructured Interview Questions

Perspective	Question
Familiarity	a. Do you know about AR technology? b. Are you interested with this tool?
Visualization	a. Show me the picture of i) heart, ii) stomach, and iii) skeleton b. Do you like this paper? (Show the comprehensive note? c. Do you like the cartoon that appears on the laptop?
Effectiveness	a. Tell me, what is muscular system? b. Is this application able to attract your attention or not? c. Would you like to use this tool again?
Entertain and fun	a. Are you happy to use this tool today? b. What do like about this tool?

Appendix G

Comprehensive Note

Appendix H
Marker

Appendix I

ARMS Exercise

Appendix J

User Manual

Appendix K

List of AR Experts

Area	Names	Organization
AR	Respondent 1	Human Interface Technology Laboratory New Zealand (HITLabNZ), University of Canterbury, New Zealand.
	Respondent 2	Lecturer, UUM, Malaysia