THE STUDY OF AUGMENTED REALITY TECHNIQUE IN SCIENCE LEARNING MOTIVATION (eSTAR)

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Abstrak

Tujuan kajian ini adalah untuk mencadangkan satu prototaip Buku Teks Sains dipertingkatkan menggunakan Realiti Luasan (eSTAR) sebagai bahan pembelajaran sains tambahan bagi pelajar Tingkatan II. Kementerian Pendidikan Malaysia telah mewujudkan polisi 60:40 di mana ia mensasarkan 60 peratus pelajar untuk aliran sains manakala 40 peratus untuk seni. Walau bagaimanapun, statistik menunjukkan bahawa terdapat trend menurun dalam enrolmen pelajar dalam bidang sains untuk beberapa dekad yang lalu. Nisbah pelajar sains kepada seni dalam tahun 80-an adalah 31:69, kemudian turun kepada 22:78 dalam tahun 90-an dan kekal pada 29:71 pada tahun 2012. Dari kajian awal, didapati pelajar mempunyai minat dalam bidang sains; walau bagaimanapun, mereka kurang motivasi untuk terus melanjutkan pelajaran dan kerjaya yang berkaitan dengan sains. Oleh itu kajian ini mencadangkan prototaip eSTAR yang menggabungkan Realiti Luasan (AR) dan teknologi multimedia (MM) berdasarkan model konsep eSTAR. Metodologi yang digunakan dalam kajian ini diadaptasi daripada Metodologi Kajian Sains Reka Bentuk. Prototaip menggabungkan Model Motivasi ARCS, Teori Kognitif Pembelajaran Multimedia, Teori Motivasi Intrinsik dan Prinsip Multimedia. Prototaip ini dinilai oleh 140 sampel pelajar Tingkatan II menggunakan reka bentuk eksperimen dan borang kajiselidik. Dapatan penilaian menunjukkan bahawa menarik, kenikmatan dan menyeronokkan adalah berkait rapat secara signifikan dengan motivasi. Kajian prestasi pembelajaran menunjukkan bahawa melalui penggunaan prototaip eSTAR, pelajar berupaya meningkatkan prestasi berbanding dengan kaedah pembelajaran konvensional. Model konsep dan prototaip eSTAR adalah sumbangan paling penting kajian ini. Kajian ini membuktikan bahawa penggunaan Realiti Luasan dalam pembelajaran sains mampu memotivasikan pelajar untuk mencapai prestasi yang lebih baik dalam sains. Hasil kajian ini boleh membantu Kementerian Pendidikan mencapai dasar 60:40 agar Malaysia dapat bergerak ke arah menjadi sebuah negara maju menjelang tahun 2020.

Kata kunci: Realiti Luasan, Multimedia, pembelajaran sains, motivasi, prestasi pembelajaran, dasar 60:40 (Sains: Sastera)

Abstract

The purpose of this study is to propose an Enhanced Science Textbook using Augmented Reality (eSTAR) prototype as a supplementary science learning material for Form II students. The Ministry of Education of Malaysia has established a 60:40 policy whereby it targets 60 percent of the students for science stream while 40 percent for arts. However, statistics indicate that there is a downward trend in the enrolment of students in science for the past few decades. The ratio of science to arts students in the 80's was 31:69, then declined to 22:78 in the 90's and remained at 29:71 in 2012. From the preliminary study, it was found that students have the interest in science; however, they are less motivated to continually pursue their higher education and careers related to science. Thus, this study proposes the eSTAR prototype which incorporates Augmented Reality (AR) and Multimedia (MM) technologies based on eSTAR conceptual model. The methodology utilized in this study is adapted from the Design Science Research Methodology. The prototype incorporates the ARCS Model of Motivation, Cognitive Theory of Multimedia Learning, Intrinsic Motivation Theory and Multimedia Principles. This prototype was evaluated among 140 samples of Form II students using experimental design and questionnaire. The results of the evaluation show that engaging, enjoyment and fun are significantly related to motivation. The learning performance study indicates that through the use of the eSTAR prototype, students are able to perform better compared to the conventional learning method. The eSTAR conceptual model and its prototype are the most important contributions of this study. This study proves that the use of AR in science learning is able to motivate students to perform better in science. The output from this study may assist the Ministry of Education to achieve the 60:40 policy as Malaysia moves towards becoming a developed nation by the year 2020.

Keywords: Augmented Reality, Multimedia, science learning, motivation, learning performance, the 60:40 (Science: Arts) policy

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List of Abbreviations

MM	Multimedia
VR	Virtual Reality
AR	Augmented Reality
LSS	Live Solar System
UCD	User Centered Design
HHD	Hand Held Display
HMD	Head Mounted Display
MoE	Ministry of Education
3D Model	Three Dimensions Model
MoHE	Ministry of Higher Education
MDP	Multimedia Development Process
CTML	Cognitive Theory of Multimedia Learning
IMMS	Instructional Materials Motivation Survey
HIT Lab	The Human Interface Technology Lab
ARCS	Attention, Relevance, Concentration and Satisfaction
TIMSS	Trends in International Mathematics and Sciences Study
ADDIE	Analysis, Design, Development, Implementation and Evaluation

CHAPTER ONE
INTRODUCTION

1.1 Research Background

As a developing country that is moving towards becoming a developed country, Malaysia needs more human resources and expertise in various fields related to science and technology. They allow Malaysia to explore, find, capture, and sometimes monopolize a variety of disciplines and natural wealth and generate substantial returns in many aspects of life. Moreover, the government has decided that Malaysia should be enhanced to become a fully developed and industrialized country by the year 2020. This is in line with Vision 2020, which is the vision of Tun Dr. Mahathir Mohamad, the former Prime Minister of Malaysia. According to Tun Dr. Mahathir Mohamad (1991),

"The goal is to make Malaysia the country's development"... as an industrial nation "and"... the formation of a Malaysia that is fully developed, by the year 2020 according to our own..." (Mohamad, 1991).

As a developing country, mastery in various fields of science and technology will enable Malaysia to build the strength to be competitive with other developed countries such as the United States of America, United Kingdom, Germany and Japan (Rahim, 2012). Those countries not only intensify their efforts to master the various fields of science and technology, but also often give priority to the education sector budget respectively (Rahim, 2012). Hence, these proved that a developing country does not solely depending on the source of capital and technology development (Rahim, 2012). In fact, the quantity and quality of manpower and the ability to adapt to the latest technology should be considered as well (Rahim, 2012). It is very important to the success of science and technology policy goals of ensuring scientific development to sustain high rates of economic growth and accelerate industrial development (Rahim, 2012).

Science learning should be given more priority since it plays a major role in assisting a country to achieve the developed country status (Tobin, 2015; Talib, Luan, Azhar & Abdullah, 2009). In order to achieve the status, it requires more skilled workers in science related careers such as medical, engineering, and technical fields. Moreover, science and technology is the fundamental force behind the economic development of developing nations (Tobin, 2015; Rahim, 2012). Accordingly, school is the very first platform where students learn science. The achievement and progress in science learning in school is very prominent and must be given more priority (Wellcome, 2015). In Malaysia, science is one of the core subjects in primary and secondary schools. In the contemporary era, science learning in secondary school is considered very prominent because it provides students with the knowledge and skills that enable them to solve problems. Moreover, it helps to make right decisions in everyday's life based on attitude and scientific values. Science learning leads to critical and creative thinking.

Former Deputy Prime Minister and Education Minister Tan Sri Muhyiddin Yassin proposed plans to encourage and motivate more students to involve in science learning and science related professions (Perimbananayagam & Dzulkafli, 2012). He has proposed a tax incentive for parents who enrolled their children into the science stream (Kok, 2012; Perimbananayagam & Dzulkafli, 2012) and increased the amount of the Federal Minor Scholarship for Form Four and Five science students from RM70 to RM200 monthly and the University Preparatory Class Scholarship for Form Six students from RM110 to RM300 monthly.

The Ministry of Education provides comprehensive science textbooks for secondary schools to be used as the main reference for science learning. The books consist of text and images which are mostly in black and white and only a few pages are in colours. Science learning involves many dynamic concepts which are difficult to be explained simply by using text and images alone. Thus, supplementary learning materials are required since some dynamic concepts are difficult to explain in the traditional method of teaching (Hwang, Tam, Lam & Lam, 2012; Aziz, Nor, & Rahmat, 2011). Sometimes students failed to imagine and understand the actual meaning of a scientific process (Hwang et al., 2012; Aziz et al., 2011). Thus, science learning requires a new method that allows students to understand dynamic science concepts more easily compared with conventional learning method.

The advancements of new technologies over a decade ago have led to the adoption of a plethora of new tools and techniques in teaching and learning. AR and MM are examples of the technologies that hold a lot of potential in science learning. According to Solak & Cakir, 2015; Tsou, Wang & Tzeng (2006), MM elements such as text, image and animation provide versatile and effectual learning. AR is a new medium of combining aspects of ubiquitous computing, tangible computing and social computing (Yerushalmy & Weizman, 2012). This medium combines physical and virtual worlds with continuous and implicit user control of the point of view and interactivity (Diegmann, Schmidt-Kraepelin, Eynden, & Basten, 2015; Radu, 2014; Billinghurst & Dunser, 2012). AR is a technology for presenting real-time overlay of virtual computer graphic image on top of actual image captured by the camera (Billinghurst & Dunser, 2012). AR can be applied to training and education (Diegmann et al., 2015; Lee, 2012) and the method can enhance the user's motivation with the real world (Diegmann et al., 2015; Solak, & Cakir, 2015; Rasalingam, Muniandy, & Rass, 2014; Billinghurst & Dunser, 2012). AR provides a unique visual and interactive experience which combines the real and virtual information. Utilizing AR in education stimulates creative thinking and enhance their comprehension towards the subject (Diegmann et al., 2015; Tobin, 2015; Billinghurst & Dunser, 2012). However, the potential of AR is not fully utilized in education domain especially in science learning (Diegmann et al., 2015; Wu, Lee, Chang & Liang, 2012; Chen & Tsai, 2012; Kerawalla, Luckin, Seljeflot, & Woolard, 2006). Hence, this study was undertaken to investigate deeper into the use of AR in science learning and also to examine the effect of AR on the students' motivation in science learning (Diegmann et al., 2015; Solak & Cakir, 2015; Rasalingam et al., 2014).

1.2 Problem Statement

Malaysia is one of the developing nations and leading towards becoming an industrialized nation by the year 2020. Thus, mastery in the fields that are related to science and technology is crucial among the people. In realizing the aspiration to make Malaysia a developed country, one of the main conditions that need to be fulfilled is to have enough skilled and knowledgeable workers and professionals in various fields that are related to science and technology. Unfortunately, Malaysia is facing a downward trend in science-related professions and careers among younger generations over a few decades (Hassan, Awang, Ibrahim, & Zakariah, 2013; Osman, Halim, & Meerah, 2006). As such, the government has set a goal and established a 60:40 (60% Science and 40% arts) of education policy in order to balance the number of students studying in science and technology over arts. The policy was established in 1967 with the aim of producing more scientists, engineers, doctors and technicians of high expertise for developing the various economic and social sectors of Malaysia (Hassan et al., 2013; Rahim, 2012). This is in line with the increase in population and quality of life (Rahim, 2012). Science and technology will enable Malaysia to build the strength to be competitive with other developed countries.

According to former Education Director Datuk Dr. Abdul Shukor Abdullah, the tendency of students to enter the science stream at the secondary level is still low since 1970s (Berita Harian,1999 cited by Rahim, 2012). In the mid 1980's, the ratio of science to arts students declined to 31:69; in 1990's the ratio declined further to 22:78 and it remained at 20:80 until 2012 (Sung, 2013). Moreover, only 29% of the students are pursuing science stream in the secondary schools (Hassan et al., 2013; Berita Harian cited by Shahrim, 2012). Trends in the International Mathematics and Science Study (TIMSS, 2011) (Martin, Mullis, Foy, & Stanco, 2012) reported that the interest among form two students in science learning have been declined approximately 17% from the year 2003 to 2011 (Sung, 2013) as shown in Figure 1.1. Meanwhile, according to Prof. Dr. Halimaton Hamdan, the science stream students in local universities were only around 35,000 a year, where it should be 100,000 a year (Berita Harian cited by Shahrim, 2012).

Figure 1.1. The TIMSS 2011 scale on science achievement
(Source: TIMSS 2011 Report)

There are many external factors affecting the students' attitudes towards the science subject and they become less positive from the age of 11 to 16 (Osborne, Simon & Collins, 2003; Breakwell & Beardsell 1992; Doherty & Dawe 1988; Johnson 1987; Yager & Penick 1986; Simpson & Oliver 1985; Smail & Kelly 1984; Hadden & Johnstone 1983; Harvey & Edwards 1980; Brown 1976 as cited by Osborne et al., 2003). Mahamad, Ibrahim & Taib (2010) reported that students and teachers have hectic schedules every day which make the students hard to follow everything that have been taught every day and the teachers have limited time to teach each subjects. Other than that, students are from the z generation who are born in privileged with internet (Oh, & Reeves, 2014; Pasaréti, Hajdú, Matuszka, Jámbori, Molnár, & Turcsányi-Szabó, 2011). They are gadget-geeks and grown up with digitals (Oh, & Reeves, 2014; Arnone, Small & Chauncey, 2011; Pasaréti et al., 2011). So, when they are using textbooks with only text and images as contents, they have very little interest and would easily get bored with the books (Oh, & Reeves, 2014; Pasaréti et al., 2011). Basically, students have their interest in science learning but it is not convinced or motivated enough to pursue their career in science based profession (Osborne et al., 2003). This circumstance leads students to lack of motivation. Motivation is an act which encourages someone to do some action (Guay, Chanal, Ratelle, Marsh, Larose, & Boivin, 2010). Motivation is salient for every individual especially for students. In a learning environment, motivation deals with the problem of setting up conditions so that the learners will perform the best of their abilities in academic (Solak, & Cakir, 2015; Guay et al., 2010).

Meanwhile, many researchers have conducted studies to enrich the conventional teaching method with textbook (Matcha & Rambli, 2011) in contrast to enhancing the teaching method so that the students attitude towards science could be changed (Arunachalam, 2014). Other than that, the way the teaching materials presented in the classroom might probably be one of the reasons why students found science learning is difficult (Rasalingam et al., 2014; Phang, Abu, Ali, & Salleh 2012; Aziz et al., 2011).

In the learning process, active learning requires the learners to learn new information and find ways to put it to use (Mayer, 2008). Active learning resulted in learners to have better retention and understanding of the learning process (Mayer, 2008). Moreover, the younger generations have the natural feeling of curiosity to explore new environments and prefer to involve in actively moving activities (Oh, & Reeves, 2014; Arnone et al., 2011). The conventional learning method bores the students after some time and they lost their focus in their studies (Rasalingam et al., 2014; Pasaréti et al., 2011).

There are numerous benefits of the AR technology in teaching and learning identified in past studies and it is highly recommended to incorporate in the education domain (Wu et al., 2012; Pasaréti et al., 2011; Arnone et al., 2011). In this study, it has been identified that lack of motivation among the students in Malaysia is one of the main reasons for the declining interest in science (Phon, Ali & Halim, 2014; Phang et al., 2012; Talib et al., 2009). The AR technology has been proven to have good potential in education (Rasalingam et al., 2014; Pasaréti et al., 2011; Wu et al., 2012), however, it has not been adopted much into the education settings due to financial constraint and the lack of the needs of AR in academic (Wu et al., 2012; Pasaréti et al., 2011). In order to sustain the students' focus and enhance motivation in learning, this study proposes ease of use, engaging, enjoyment and fun as measurements to be integrated in textbook learning. It is proved that ease of use able to increase the understanding of the learning contents (Radu, 2014; Rambli, Matcha & Sulaiman, 2013). Other than that, according to Radu (2014), AR enhances the enthusiasm to continually engage, having fun and having enjoy in a learning process. Moreover, the feeling of fun and enjoyment motivate students and plays vital role in enhancing the academic achievement (Solak, & Cakir, 2015). Through obtaining a good grade in science, the misconception towards science learning can be resolve and encourage to pursue science related higher education and professions. Based on Solak and Cakir (2015), academic achievement and motivation shares a highly positive correlation. Thus, the increment in academic achievement will increase the motivation level of students.

According to Solak & Cakir (2015) and Talib et al., (2009) there were plenty of researches have been done on student's misconception and conceptual understanding in science subject. According to Dermitzaki, Stavroussi, Vavougious & Kotsis (2012), further research is required to study on the quality and level of motivation among different groups. Few studies have been conducted in enhancing the learning process especially in science learning (Arunachalam, 2014; Azer, Guerrero, & Walsh, 2013). Unfortunately, none of them studied on the students' learning performance. So far, they only provided the perceptual results which have the tendency to change at any time.

1.3 Preliminary Study

A preliminary study has been conducted to confirm the research problem. It is an initial exploration of related issues in order to propose a better solution (Shiratuddin & Hassan, 2010). A survey was conducted as part of the preliminary study in a secondary school located in Perak. The form 2 students from the school were chosen to participate in this preliminary study. A set of questionnaires (refer to Appendix C) were used as an instrument and distributed to all five classes with a total of 108 respondents. The questions focused on the issues related to the current and conventional approach of science learning in Malaysia. Table 1.1 shows the questions that were asked to the students and displays the results of the preliminary study.

Table 1.1

Preliminary Investigation Questions and Results

Questions	Yes	No
Are you interested in the subject of Science?	96%	4%
Is learning science in the classroom interesting and fun?	84%	16%
Is that your science text book is interesting and motivating?	85.73 %	14.27 %
Would you like to learn science using textbooks	64%	36%
Are you referring to additional learning materials other than textbook science?	60%	40%
Does the additional learning material in the form of printed books?	50%	50%
Do you use the Internet to obtain additional learning materials for science?	65%	35%
Does the use of supplemental learning materials for Science in the form of video and animation can increase your interest to learn science?	70%	30%
Have you been doing experiments in science labs?	100 %	0%
Are you able to understand a simple concept through experimental science?	99%	1%
Do you want a change in the method of learning science?	87%	13%

From this study, 96% of the students stated that they are interested in science and 85% of the students indicated that science learning in the classroom is interesting and fun. 85.73% of them stated that the science textbook is interesting and motivating but only 64% like to learn science using textbooks. 60% of them referred to additional learning materials besides the science textbook which include printed books (50%) and online science materials (65%). 70% of the students agreed that supplemental learning materials in the form of video and animation can increase their interest to learn science. All the students have been doing experiments in science labs and 99% of them were able to understand a simple science concept through experiment. This proves that students preferred active learning environment where they can apply their knowledge and gain experience through their practical activities. Finally, 87% of the students wanted a change in the method of learning science.

According to Mayer (2008), the integration of both behavioral and cognitive activities tends to lead to better retention and positive outcomes from a learning process. It is clear that students are interested in science subject but they are expecting some changes in the teaching method. They preferred the active learning environment compared to the conventional chalk and talk approach in the classroom. The results of the preliminary study provide clear evidence of the need and relevancy of this study.

1.4 Research Questions

The problems discussed above lead to the following questions to be investigated in this study.

i. How to conceptualize a model of an Enhanced Science Textbook using AR in motivating students to learn science?
ii. How to develop the AR Enhanced Science Textbook in motivating students to learn science?
iii. What is the relationship between the students' motivation towards Enhanced Science Textbook using AR?
iv. What is the students learning performance towards Enhanced Science Textbook using AR?

1.5 Research Objectives

This research aims to propose an enhanced science textbook using AR (eSTAR) for form two students. In order to successfully achieve the main objective, five sub-objectives are introduced. The sub-objectives function as guidelines for this study and are as follows:

i. To construct a conceptual model in designing the eSTAR.
ii. To design and develop the eSTAR based on the conceptual model.
iii. To measure and determine the relationship between students' motivation towards the use of Enhanced Science Textbook using AR.
iv. To measure students learning performance with the intervention of Enhanced Science Textbook using AR in Science learning.

1.6 Research Hypotheses

The following section discusses the hypotheses that have been formulated for this study. Six hypotheses were constructed and the probability level of 0.05 was used to test for the inferential statistic significance. Besides inferential statistics, the hypotheses are also discussed in descriptive statistics in Chapter Five (Data Analysis and Result).

Hypothesis $_{01}$: There is no significant relationship between Ease of use and motivation in the eSTAR prototype.

Hypothesis $_{02}$: There is no significant relationship between Engaging and motivation in the eSTAR prototype.

Hypothesis $_{03}$: There is no significant relationship between Enjoyment and motivation in the eSTAR prototype.

Hypothesis $_{04}$: There is no significant relationship between Fun and motivation in the eSTAR prototype.

Hypothesis $_{05}$: There is no significant difference in the respondents' learning performance between the pre-test and post-test means scores of the control group.

Hypothesis $_{06}$: There is no significance difference in the respondents' learning performance between the pre-test and post-test means scores of the experimental group.

1.7 Research Scope

The central attention of this research study is to propose a conceptual model on how to develop an eSTAR prototype. A conceptual model for designing and developing the eSTAR prototype was constructed by implementing motivational theories and MM principles. There were several prominent models, theories and principles were utilized namely; the ARCS (Attention, Relevance, Confident and Satisfaction), the Cognitive Theory of Multimedia Learning (CTML), the Intrinsic Motivation Theory and Multimedia Learning Principles. In order to develop a comprehensive and effective prototype, three design components such as design for interaction, design for information and design for the presentation were comprised into this study.

Moreover, the eSTAR prototype was developed as a standalone application based on eSTAR conceptual model. Several softwares been used such as the Adobe Flash CS5, the Adobe Photoshop CS5, Camtasia Studio 7.0, and the Autodesk 3D Max 2010 and BuildAR 2.0 during the prototype development phase. The developed eSTAR prototype is focused for secondary school students (14 years old). Based on Dr. Halimaton Hamdan that students have low levels of motivation towards enrolling in science related higher education studies and professions and also facing a downward trend in students' achievements in school (Berita Harian, 1999 cited by Rahim, 2012). In order to achieve developed nation status by the year 2020, we have to excel in science and technology fields. Thus, enhancing the science learning by providing a supplementary learning material is to motivate students to perform well and pursue science related higher education and profession in the future. Moreover, it is intervened with the most futuristic and potential technology to motivate the students towards science learning. The contents for the eSTAR prototype were derived from Science textbook (form two) and several other learning materials suggested by the content experts (teachers) (See Appendix I). Table 1.2 portrays the topics comprised in the eSTAR prototype and it was developed in Malay language since in Malaysia most of the schools using Malay language to teach Science in schools.

Table 1.2

The Target Topics in eSTAR

No.	Topics
1.	Sensory organs and functions
2.	Light and vision
3.	Sound and hearing
4.	Stimulus and response
5.	Classes of food
6.	Importance of balanced nutrition
7.	Human digestive system
8.	The process of absorption of digested food
9.	Reabsorption of water and bowel movements
10.	Healthy eating practices

The developed prototype was evaluated amongst students to determine their perceptions towards using the prototype as well as to determine the correlation between the independent variables and the dependent variable. The pre-test and the post-test were also conducted to determine the learning performance of the students with the intervention of the eSTAR prototype.

1.8 Research Significance

This study holds significance for students, teachers, educators and researchers. The most important is the expected contributions from the study of interactive multimedia learning environment through the use of enhanced science textbook in motivating students to be more interested in science. As Malaysia is moving towards becoming a developed nation by 2020, the declining number of students pursuing the science stream in secondary schools is very worrisome. The proposed eSTAR prototype promises a low cost, attractive, fun, and interactive outside the class learning environment for students in gaining better comprehension in science. It is hoped that through the use of eSTAR, students are more motivated towards science learning and eventually pursue their careers in science based professions.

The results of this study could help policy makers, teachers, educators and researchers make important decisions. These include incorporating the proposed solution into the conventional approaches of science learning by providing avenues for future studies related to interactive multimedia learning environment through the use of enhanced textbook. By the end of this study, three contributions are expected. Firstly, the proposed model for designing and developing the interactive multimedia learning environment through the use of enhanced science textbooks. Secondly, the eSTAR prototype is the most important contribution of this study which can be used to motivate students to be more interested in science. Finally, the results from the perceived science learning motivation evaluation based on the use of the proposed prototype will demonstrate the potential of the prototype in motivating students to be more interested in science learning.

1.9 Conclusion

In conclusion, this chapter has discussed the problem statement and the research questions. It also discussed the objectives to be achieved, the scope and the expected outcomes and significance of the proposed solution. The topics discussed in this chapter are important as the guideline to the study. Therefore, this chapter can be described as a conceptual understanding of the concentrated study.

1.10 Summary of This Research Study

Table 1.3

Summary of This Research

Research Problem
In order to achieve developed nation status by the year 2020, government need more human force from science related career. So, government set policy of 60:40 (60 percent from science and 40 percent from arts). Unfortunately, Identified a downward trend in pursuing science based career and higher education among younger generation. This circumstance occurs due to lack of motivation. Therefore, this study proposes learning with the AR and MM intervention to motivate students.
Research Question
i. How to conceptualize a model of an Enhanced Science Textbook using AR in motivating students to learn science? ii. How to develop the AR Enhanced Science Textbook in motivating students to learn science? iii. What is the relationship between the students' motivation towards Enhanced Science Textbook using AR? iv. What is the students learning performance towards Enhanced Science Textbook using AR?
Research Objective
i. To construct a conceptual model in designing the eSTAR. ii. To design and develop the eSTAR based on the conceptual model. iii. To measure and determine the relationship between students’ motivation towards the use of Enhanced Science Textbook using AR. iv. To measure students learning performance with the intervention of Enhanced Science Textbook using AR in Science learning.
Research Methodology
Awareness of Problem ➡ Suggestion ➡ Development ➡ Evaluation ➡ Conclusion (Kuechler & Vaishnavi, 2011)

Research Hypothesis
Hypothesis $_{01}$*:* There is no significant relationship between Ease of use and motivation in the eSTAR prototype. *Hypothesis* $_{02}$*:* There is no significant relationship between Engaging and motivation in the eSTAR prototype. *Hypothesis* $_{03}$*:* There is no significant relationship between Enjoyment and motivation in the eSTAR prototype. *Hypothesis* $_{04}$*:* There is no significant relationship between Fun and motivation in the eSTAR prototype. *Hypothesis* $_{05}$*:* There is no significant difference in the respondents' learning performance between the pre-test and post-test means scores of the control group. *Hypothesis* $_{06}$*:* There is no significance difference in the respondents' learning performance between the pre-test and post-test means scores of the experimental group.

Table 1.3 depicts the summary of this research study. This table comprises the research problem of this thesis. Followed by, the formulated research questions, research objective, research method and research hypothesis if this study in order to achieve the aim which is to prove that AR in science learning provides engagement, enjoyment and fun. Meanwhile, it is also motivate students to perform better.

1.11 Summary of All Chapters

This thesis consists of six chapters. The following sections are the summaries for each chapter.

Chapter One: Introduction

This chapter provides the introduction regarding to the overall thesis. This chapter consists of several sub-sections which are research background, problem statement, preliminary study, research questions, research objectives, research hypothesis, research scope, research significance and conclusion for the chapter.

Chapter Two: Literature Review

This chapter discusses regarding the past studies and discusses the implemented elements, theories and model in this study. Furthermore, it is discusses about the computer technologies such as AR and MM together with related theories, principles and how it is connected to this research study.

Chapter Three: Research Methodology

Third chapter discusses the adapted research methodology and how the method going to implement in this research study. This study adapted Kuechler & Vaishnavi's research methodology which has five main phases namely; awareness of the problem, suggestion, development, evaluation and conclusion. Furthermore, it also discusses about the three design guideline and adapted model namely ADDIE Model in order to guide the developing of eSTAR prototype and the constructed conceptual model.

Chapter Four: Design and Development of eSTAR Prototype

This chapter depicts the designing and developing of the eSTAR prototype. In this chapter, it discusses all the process while developing the eSTAR prototype.

Chapter Five: Data Analysis and Results

Chapter five discusses about the results collected from conducted evaluation. In this study the heuristic evaluation, the perception study, the Pearson Correlation, the regression and the performance study have been conducted.

Chapter Six: Conclusions

This is the final chapter for this research study. It concludes all the all the findings and mentions the limitation and recommendations of the study. Further, it does also discuss regarding the contribution to the body of knowledge and suggestion for future study.

CHAPTER TWO
LITERATURE REVIEW

2.1 Overview of Literature Review

Multimedia is a growing technology and implemented in almost all domains like education, business, medical, engineering, entertainment and sports. A study of previous literatures related to the subjects is important to observe the idea of the selected study. The following review of literatures provides the background knowledge of the study pertaining to the concept of AR and MM. This chapter discusses on some prominent theories and models which are related to multimedia and Augmented Reality implemented in learning.

2.2 Multimedia Definition

Multimedia is a combination of texts, graphic arts, sounds, animations and videos that is displayed using the computer (Yong, 2013; Smith, 2013; Gilakjani, 2012). In common usage, multimedia refers to an electronically delivered combination of media including video, images, audio, text in such a way that can be accessed interactively. Computers marketed in the 1990's were referred to as "Multimedia Computers" because they contained a CD-ROM drive. Multimedia can be defined in multiple manners since it depends upon one's perspective. The computers are the medium for Multimedia to present text, audio, video, animation, interactive features, and images in various ways and multiple coalitions of various elements. So then, the elements could be conveying a message or information to audiences is made possible through the current development of technology (Gilakjani, 2012).

2.3 Interactive Multimedia

The rapid development of multimedia technology has introduced the interactive multimedia. The interactive multimedia is derived from the words interactive and multimedia where interactive means allowing the knowledge transfer to be occurred between human and computer continuously (Oxford Advanced Learner's Dictionary, 2000) while multimedia is defined as above. Naturally, multimedia can deliver a high quality of the learning environment. Moreover, when integrated with interactivity, multimedia enhances the learning process through an integrated learning environment (Chiou, Tien, & Lee, 2015; Thiyagu, 2013; Rambli et al., 2012; Dunser, Walker, Horner, & Bentall, 2012; Muhamad, Mansor, & Lily, 2010). The interactive multimedia involves digital storytelling in all of its aspects, visual innovation, and computational creativity with the combinations of electronic texts, graphics, moving images, and sound, into a structured digital computerized environment that allows users to interact with the data for appropriate purposes (Chiou et al., 2015; Thiyagu, 2013; Aziz et al., 2011).

2.4 Multimedia Elements

Multimedia have been applied in a plethora of human lives, namely; education (Lee, 2012), business (O'Reilly & Samarawickrema, 2011) and training (Lee, 2012). Multimedia originates from two separate words; "multi" and "media". "Multi" means various whereas "media" refers to any hardware or software used in the field of Information and Communication Technology (Yong, 2013). The multimedia applications can include many types of media. The primary characteristic of a multimedia system is the use of more than one kind of media to deliver content and functionality. Both the Web and the desktop computing programs can comprise all multimedia components and deliver the content. As well as different media items, a multimedia application will normally involve programming code and enhanced user interaction. The Multimedia elements generally fall into one of five main categories as shown in Figure 2.1.

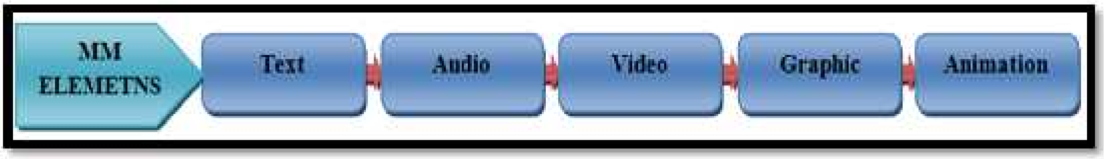


Figure 2.1. Multimedia elements

2.4.1 Text

Text is the most commonly used and flexible means of presenting information on screen and conveying ideas. Text plays a prominent role in presenting the information (Rodgers, 2014). The combination of texts and other media to deliver functionality is the most widely utilized in most part of the multimedia system. Texts in multimedia systems can express specific information, or it can act as reinforcement for information contained in other media items (Rodgers, 2014). For example, when Web pages are included with image elements, they can also include a short amount of text for the user's browser to include as an alternative, in case the digital image item is not available. Since text is a salient part of a material, designers should consider a text layout, a text format and the text quality as suggested by Allesi and Trollip (2001).

2.4.2 Graphic

Alessi and Trollip (2001) described four major applications of graphics which include; as the primary of information, as analogies or mnemonics, as organizers and also as cues. In MM, the graphics are the visual presentations on some surface. The use of graphics establishes attraction, communication and direct attention to the users. Usually, the use of graphics in a textual information delivery promises better memory retention to the users. Moreover, complex information that needs users' understanding is better projected and understandable by using graphic presentation (Schar & Krueger, 2000). Graphic software such as Adobe Photoshop and Adobe Illustrator allow developers to create complex visual effects to the digital images. Some of the graphic formats include BMP, TIFF, GIF, JPEG, PNG and SVG.

2.4.3 Audio

Audio plays a major role in some multimedia systems. Rodgers(2014) have pointed out that audio has obvious advantages for presenting simple material to learners as an alternative to printed texts for users that have poor reading skills. Audio can attract user's attention away from his or her current task. The combination of visual presentation with audio explanation also delivers information in an easily understood format (Mayer, 2001). Some of the audio formats include MP3, WMA, Wave, MIDI and Real Audio.

2.4.4 Video

Video can record a motion that occurs in the real world. Rodgers (2014) and Alessi & Trollip (2001) indicated that a video can be entertaining, engaging and provoking. Digital videos appear in many multimedia applications which include web sites such as YouTube. Similar to audio, websites can stream digital videos to increase the speed and availability of playback (Rodgers, 2014). The common digital video formats include Flash, MPEG, AVI, WMV and QuickTime. Researchers have recognized that a video is not an ideal medium for presenting detailed material, but is best used for broader, abstract material, possibly with an emotional appeal (Smith, 2013). Video presentations are generated from video files that consume a lot more storage space than simple animations.

2.4.5 Animation

An animation is an excellent way to add visual impact to the multimedia presentation (Chiou et al., 2015; Rodgers, 2014). A computer animation refers to any application which generates a series of frames so that each frame appears as an alteration of the previous one and where the sequence of frames is determined either by the designer or the user (Betrancourt & Tversky, 2000 as cited by Ainsworth, 2008). Animations include interactive effects which allow users to engage with the animation action using a mouse and a keyboard. Animated components are common within both the Web and the desktop multimedia applications. Animation can be classified as 2D and 3D animations. The most common tool for creating 2D animation on the Web as well as for the desktop application is the Adobe Flash. Through the Adobe Flash, developers can author the FLV files, exporting them as SWF movies for deployment to users (Smith, 2013). The Adobe Flash uses the Action Script codes to achieve animated and interactive effects. Most 3D modelers such as 3ds Max, Maya, Blender and Light wave can be used to produce 3D animations. The 3D animations videos are normally produced in the AVI format and then converted to smaller video formats such as the FLV and the MP4 for portability (Smith, 2013).

2.5 Multimedia Learning

Mayer and Moreno (2003) defined multimedia learning as learning from words and images. They further elaborate words as printed (on-screen text) or spoken (narration) while images as static (illustrations, graphs, charts or maps) or dynamic (animation, video or interactive illustration). Meanwhile, Mayer (2001) claims that learning is the process of knowledge alteration in the long term memory. Furthermore, the definition of multimedia learning can be viewed from two perspectives; firstly, multimedia learning as information acquisition and information delivery system and secondly, multimedia learning as knowledge construction and multimedia is a cognitive aid (Kalyuga, 2013; Mayer, 2001).

Apart from that, multimedia learning can encourage and perpetuate a learner's motivational level (Hu, 2008). The use of various multimedia elements enables the transfer of knowledge in a simplified manner to the learner and engage with the presented academic content. Thiyagu, 2013; Gilakjani, 2012 claims that when it comes to multimedia learning, the learner is not only engaged with the environment but also increase the participation, self-directed learning in the quest for the information, interactive and provide a media-rich learning environment.

The curiosity enhances the motivational level of learners and encourages them to be positive toward the learning incorporated with technology (Arnone et al., 2011). This could be achieved through this study since various elements of multimedia have been incorporated into the enhanced science text book using the AR (eSTAR) prototype. Apart from that, previous researchers discovered that AR learning uses multimedia elements and presents in diversified manner actually increasing the understanding and the motivational level in a learning process (Yen, Tsai & Wu, 2013; Chen, Wu, & Zhung, 2006). The eSTAR prototype that has been proposed in this research can be utilized to motivate students to be more positive towards science learning and willing to pursue in science based related careers and profession in the future. The following sub-sections will discuss multimedia learning in detail.

2.5.1 Metaphors of MM Learning

The use of multimedia depends on the designer's underlying conception of learning. There are three metaphors of the MM learning in a multimedia learning environment (Mayer, 2008). The first metaphor is the MM learning as a response strengthening which involves strengthening or weakening a combination between a stimulus and a response. The second metaphor is the MM learning as information acquisition which involves in adding information to one's memory. The third metaphor is the MM learning as knowledge construction which is based on sense-making activity where a learner builds a coherent mental representation of the presented material. Table 2.1 summarizes the differences between the three metaphors of MM learning (Mayer, 2008).

Table 2.1

Summary of Three Metaphors of MM Learning

Metaphor	**Definition**	**Content**	**Learner**	**Teacher**	**Goal of multimedia**
Response Strengthening	Strengthening or weakening an association	Association	Passive recipient of rewards and punishment	Dispenser of rewards and punishment	Enable to practice; act as a reinforce
Information acquisition	Adding information to memory	Information	Passive information receiver	Information provider	Deliver information; act as a delivery vehicle
Knowledge construction	Building a coherent mental structure	Knowledge	Active sense -maker	Cognitive guide	Provide cognitive guidance; act as a helpful communicator

2.5.2 Goals of MM Learning

The goal of MM is not only to present the knowledge but also to provide guidance on how to process the presented information. Mayer (2001) stated that there are two goals of the MM learning; to remember and to understand information. Remembering is the ability to reproduce the presented material through a retention test. The most common tests include recalling such as writing down all learners remember after a lesson and recognition such as asking learners to select on what was presented and usually in multiple choices. Then, understanding is based on the ability to build a coherent mental representation from the presented material. In a transfer test, the learners have to solve problems that are not in the presented materials. The learners have to apply what they have learned and understand through the presented material. These two goals play a major part in multimedia learning (Mayer, 2008). Table 2.2 summarizes both goals of MM learning.

Table 2.2

Summary for Goals of MM Learning

Goal	Definition	Test	Example of test items
Remembering	Ability to reproduce presented material.	Retention	Write down all that can remember from the presented material
Understanding	Ability to build a clear representation of presenting material.	Transfer	List down some ways to improve reliability of the device from the presented material

2.5.3 Characteristics of Multimedia Learning Materials

Based on the literature, there are plenty of suggestions for designing and developing a useful and effective standalone computer based supplementary learning materials such e-book, web based learning, courseware and e-notes. According to Shank (2005), a useful and effective learning material solely depends on how the learning material being presented to the learner. Furthermore, features such as the MM elements, interactivity, instructional system and textology are very crucial in designing and developing the technology based learning material (Sambrook, 2003; Fran, 1997; Barker, 1996; Toh, 1996; Wong et al., 1996; Philips, 1996 as cited by Muhamad et al., 2010). Meanwhile, the method of conveying the information is equally important as the content of the learning material and end of the process, the presentation method will leave the impact among the user to learn the subject matter more deeply (Mayer, 2003; Mayer, 2002; Mayer & Moreno, 2002; Mayer, 2001).

Furthermore, conveying information in an effective and attractive way will enhance the intrinsic and extrinsic motivation among the user (Lee & Boling, 1999). For instance, the elements such as the fonts, images, colour combination, audio and animation should be taken into consideration (Muhamad et al., 2010; Lee & Boling, 1999). Moreover, the usage of upper case fonts and lower case should be standard and clear. Meanwhile, the selected images should be clear and applied on purpose while the selected colour combination should not be too bright or too dark while audio and animation integration assists to reduce stress (Lee & Boling, 1999). Based on Lee and Boling (1999), in order to enhance the learner's motivation in learning the interaction design together with information and presentation design should be taken into consideration. Multimedia learning presents texts and images simultaneously in order to easily understand the content and make an effect of the learner's knowledge retention (Perez-Lopez & Contero, 2013; Mayer, 2001).

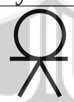
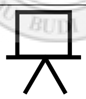
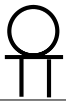
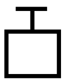
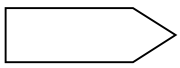
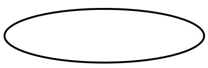
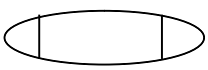
Thus, the design for interaction, design for information and design for presentation included in the designing and development of the eSTAR conceptual model as guidelines. The following sub-section will elaborate in detail regarding the design for interaction, design for information and design for presentation. The following sub-sections discuss the prominent designs in detail.

2.5.3.1 Design for Interaction

In order to deliver an effective and useful learning material for students (14 years old), the eSTAR conceptual model attempts to apply three important designs as guidelines to develop the prototype and the design for interaction is a part of the design. The design for Interaction is related to the construction and actions of an interactive system in creating fruitful relationships between the user and the product. Therefore, the User Centered Design (UCD) adapted in developing the eSTAR conceptual model (Chan & Jaafar, 2009; Constantine, 2006 cited by Nurtihah, Zulkifli, & Siraj, 2011). According to Constantine (2006) (Cited by Nurtihah et al., 2011), the UCD is the widely known and a systematic design which focuses on the entire user tasks and usage patterns well known as the interaction design in an application. Moreover, the potency of the UCD relies on its high level of abstraction provided by the model and the forthright way in which they are interrelated (Nurtihah et al., 2011). There are few notations as shown in Table 2.3 (Constantine 2006 cited by Nurtihah et al., 2011), in order to simplify designer and developer to understand the justification pertaining to the model.

Table 2.3

UCD Notations

Symbol	Name	Description
	User, User Actor	The activity participant interacting with the system
	Role, User Role	The relationship between an user actor and the system of reference
	System Actor	Non-human system (software or hardware) interacting or serving in the system of reference
	Player	The activity participant who is not interacting with the system of reference
	Artefact, Tool	Any artefact employed within the activity (system of reference)
	Activity	Collections of actions or tasks undertaken for some purposes
	Task, Task Case	Action by actors in interaction with the system of reference
	Action	Action by actors for some goal within an activity

2.5.3.2 Design for Information

The next design is the design for information which is related to the secondary school science contents (form two) in this study. The information could be conveyed in any of the MM elements such as texts, audios, videos, images and 3D models. The presented information should be suitable for the user (form two students). Therefore, the macro design strategies (from instructional strategies) were adapted in this study (Reigeluth, Doughty, Powell, Frey, & Sweeney, 1982 cited by Nurtihah, 2012). This is because it is connected to the way of conveying the selected and organized content effectively and justifiably in a simplest manner (Reigeluth et al., 1982 cited by Nurtihah, 2012). Furthermore, the eSTAR prototype should deliver comprehensive science related information to enhance the learner's knowledge retention. The content for eSTAR is referred from the form two science textbook endorsed by MoE and learning materials provided by the content experts (teachers) to make sure that the information is useful and appropriate for the target user.

2.5.3.3 Design for Presentation

The third design is design for presentation which should also be considered as it plays a major role in presenting the collected information in an attractive way to the user. In order to present the information in an effective way, the micro design strategies were adapted into this study because it is related to the method of presenting the information in a learning process. The way of presenting the information should be easily understood and leave high impact in knowledge retention (Perez-Lopez & Contero, 2013; Reigeluth et al., 1982 cited by Nurtihah, 2012). The learning materials can be in the form of texts, audios, videos, 3D models or other appropriate way which can attract the user. There are several theories based on the human cognitive process and motivation to guide the presentation design. The theories are discussed in detail in the following sections.

2.5.4 Implications of Features of Multimedia Learning Materials for this Study

In order to design and develop a useful, effective and comprehensive eSTAR prototype, the design for interaction, the design for information and the design for presentation were implemented in this study. The designs were used as a guideline and will be utilized in designing and developing the eSTAR conceptual model. Then, the elements are used to develop the proposed prototype.

2.6 Multimedia Learning Theories

The objectives in this study can only be accomplished through the construction of a conceptual model in designing and developing an Enhanced Science Textbook using the Augmented Reality (eSTAR) prototype. So that, the eSTAR prototype is capable to encourage, motivate and generate positive attitudes towards science learning among the students. The informative and effective learning materials are able to increase the students' motivation level, which leads to an excellent achievement in education. The following sub-sections discuss the overview of the related theory, model and principle that are adopted in this study which is related to multimedia learning.

2.6.1 Cognitive Theory of Multimedia Learning (CTML)

Mayer's Cognitive Theory of Multimedia Learning defines that multimedia learning occurs through constructing the mental representation using texts and images. Since, the human mind is limited in the amount of information that it can process (Mayer & Moreno, 2003). Basically, the human brain does not interpret words, pictures and auditory information in a mutually exclusive fashion, but these elements are selected and organized dynamically to produce a logical model of the MM presentation (Mayer, 2001). Thus, presenting the information through verbal (written text or audio) or pictorial (animation or pictures) produces a productive learning process (Mayer, 2003). Figure 2.2 portrays the concepts of CTML. The CTML is utilized to explain the human behavior by understanding their thought processes (Mayer, 2002). According to Mayer (2003), the CTML is based on three core assumptions as shown in Table 2.4 namely; dual channels (auditory and visual) for processing information and limited capacity of both channels. Last but not least, an active process of filtering, selecting, organizing and integrating information.

Table 2.4

Three Core Assumptions of the Cognitive Theory

Assumptions	Definition
Dual Channel Assumption	Humans possess separate information channels for processing verbal (text) and visual (image) information.
Limited Capacity Assumption	Only a limited amount of capacity for processing this information at one time.
Active Processing Assumption	Humans engage in active learning by attending to relevant incoming information, organizing the selected information into coherent mental representations and integrating the representation with other knowledge.

Moreover, the CTML focuses on three different views in a MM learning relationship with working memory mechanisms in producing an effective way of learning. There are three memory stores known (sensory memory) as the cognitive structure that allow the learners to perceive new information and the working memory to consciously process information for approximately less than thirty seconds and can only process a few pieces of material simultaneously (Mayer, 2010a). After the thirty seconds the information is transferred to the long-term memory which store the knowledge for an indefinite amount of time (De Jong, 2010). The cooperation between the MM elements in a learning process might improve the learners' long-term memory in storing information and knowledge. Through the study, Mayer (2001) has identified seven principles of nature and effect of MM presentation design to the learners. Each MM principles were discussed in depth in Chapter Four (Design and Development of eSTAR Prototype).

2.6.1.1 MM Principle

According to Mayer (2001), the MM principle emphasizes that learners learn better from words and pictures than from stand with a single word alone. So, they can easily build a connection between the models when words and pictures are both presented together.

2.6.1.2 Spatial Contiguity Principle

A near placement of corresponding words and pictures presented are better understandable rather than it far from each other on the page or screen (Mayer, 2001). Furthermore, it is easier to hold them in the working memory at the same time.

2.6.1.3 Temporal Contiguity Principle

In multimedia learning presentation, simultaneously presented corresponding words and pictures are better learned rather than successively presentation (Mayer, 2001). If the corresponding words and pictures are separated in time, the learners are less likely to hold a mental representation of both in working memory and also to build mental connections between both verbal (word) and pictorial (image) models.

2.6.1.4 Coherence Principle

Learning is better when extraneous words, pictures, and sounds are excluded (Mayer, 2001). By adding extraneous materials in multimedia learning presentation, it can divert the attention from the important materials and can disrupt the materials' organizing process.

2.6.1.5 Modality Principle

Animation and narration is better at learning than from animation and on screen text whereby the learners learn better when words in multimedia presentation are presented as spoken text rather than printed text (Mayer, 2001).

2.6.1.6 Redundancy Principle

Learning from animation and narration is better than from animation, narration, and on-screen text (Mayer, 2001). In a multimedia presentation, the visual channel can become overloaded when words and pictures are both visually presented as animation and text.

2.6.1.7 Individual Differences Principles

Individual difference principle stresses that design effects are stronger for low-knowledge learners than for high knowledge learns and for high-spatial learners rather than from low-spatial learners (Mayer, 2001). The high spatial learners possess the cognitive capacity to integrate mentally the visual and verbal representations of effective multimedia presentations and the low knowledge learners are less likely to engage in useful cognitive processing when the presentations lack guidance (Gutierrez, 2014; Kalyuga, 2013).

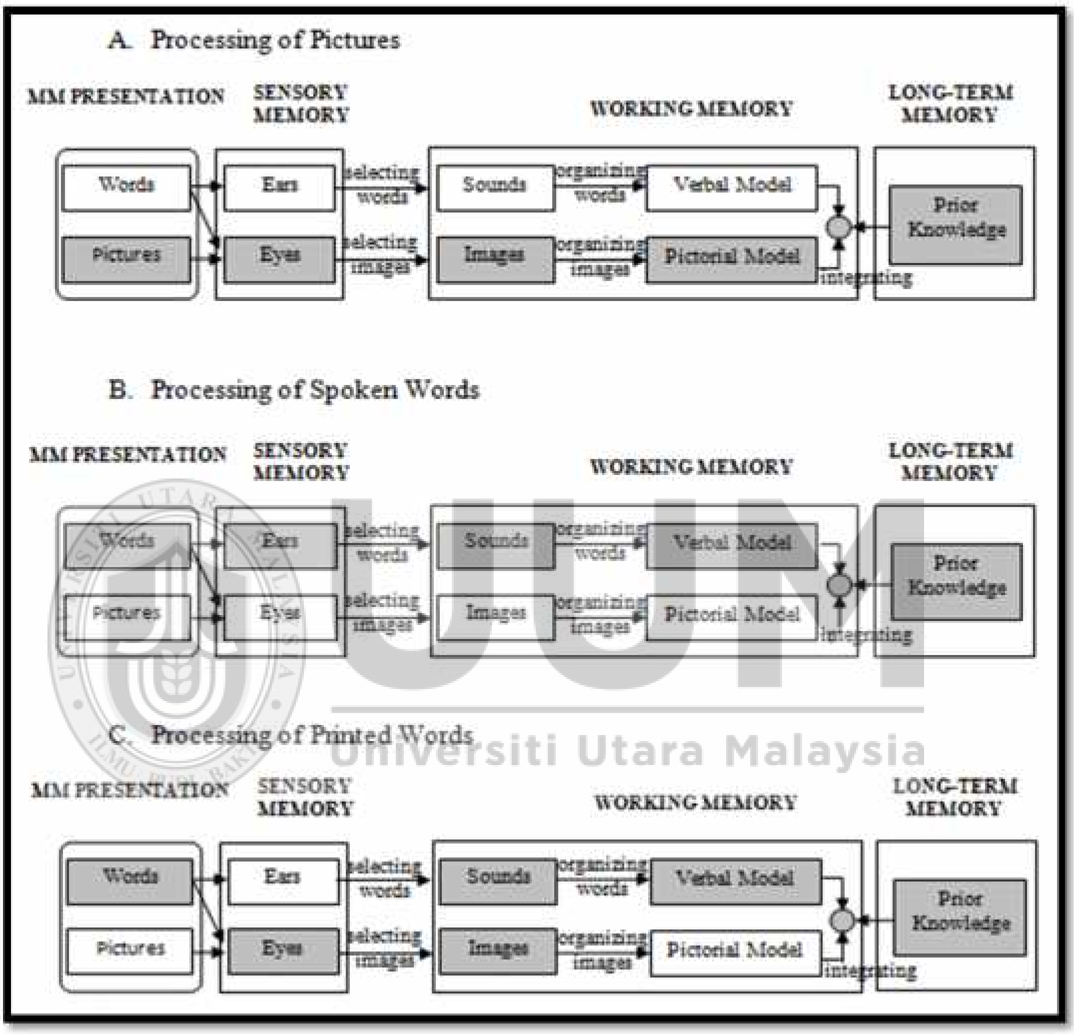


Figure 2.2. Cognitive Theory of MM Learning (Mayer, 2001)

2.6.2 Implications of MM Technology to This Study

The MM technology is a combination of various media. Thus, the CTML theory and principles that have been discussed above are the most related to the MM learning and plays a vital role in a learning material. So, the learners can present a better outcome and feedback in a learning process.

2.7 Technology and Learning Environment

Technology has the ability to convey a concept in new ways otherwise it is not possible to present it in an effective, attractive and interesting way using other instructional methods (Preston, Moffatt, Wiebe, McAuley, Campbell, & Gabriel, 2015; Kolpher, Osterweil, Groff & Haas, 2009). Besides that, implementing technologies in learning environment might bring a tremendous positive impact on the learning process (Preston et al., 2015; Arnone et al., 2011). Technology in learning environment helps the educators to present their material in a new way and also in presenting complex subject matters effectively (Preston et al., 2015; Arnone et al., 2011; Kolpher et al., 2009). This is because in the current learning process, the learners are practicing one-way communication in class where they are fully dependent on educator's knowledge and their educational contents such as textbook, PowerPoint presentation and handouts (Aziz et al., 2011; Norjihan, Norhana & Noor, 2006). There is no other reliable educational sources for learners to refer to which can take over the educator's position in teaching and learning process. The implementation of technology in the learning process leads to self-learning where learners can experience a deeply engaging, fun, effective and entertaining learning process (Phon et al., 2014; Arnone et al., 2011; Pasaréti et al., 2011; Kolpher et al., 2009). By the way, using technology such as computer, internet and other e-learning materials for learning would not be a problem for learners since they have already spent countless hours immersing in the popular technologies and social media such as Facebook, Twitter, My Space, Skype and Yahoo Messenger (Preston et al., 2015; Phon et al., 2014; Rodgers, 2014; Arnone et al., 2011; Pasaréti et al., 2011; Allyn, 2011; Kolpher et al., 2009; Norjihan et al., 2006). Moreover, the knowledge oriented learning experience might help the learners not only to score in the examinations but also can be applied for their future endeavours.

2.7.1 Traditional Teaching Method and Technology Integration in Learning

In the traditional teaching method, the teachers transfer their knowledge of matters to students as senders and the students receives the presented knowledge and learning material as receivers (Damodharan & Rengarajan, 2012 as cited by Sachou, 2013). The learning material by the teachers was delivered through the textbook, chalk-and-talk and extended to the whiteboard (Aziz et al., 2011; Pasaréti et al., 2011; Tan, Lewis, Avis & Withers, 2008) method of teaching indeed; still involving instructional media which are mainly textual (Damodharan & Rengarajan, 2012 cited by Sachou, 2013). Basically, the instructional process of the content is controlled by the sender (teacher). The teachers tend to emphasize factual knowledge and deliver the content to the entire class (Azer, 2013; Thakur, 2013; Damodharan & Rengarajan, 2012 cited by Sachou, 2013). In general, the interaction between the sender and the receiver occurred only within a passive environment where the sender (teacher) controls the teaching and learning environment (See Figure 2.3).

Figure 2.3. Traditional teaching methods

The model in Figure 2.3 depicts that the teacher controls the teaching and learning process. The teacher plays a vital role in a learning process where the learning materials are conveyed to the entire class and the teacher stresses on factual information. Besides that, the student as the receiver observes the lecture while the teacher presents the teaching content. Meanwhile, Orlich, Harder, Callahan, Trevisan and Brown (2009) stated that the learning mode tends to be more passive as students (learner) only play a small part in a learning process compared to the presenter, the teacher. The traditional teaching method turns students into passive receivers of the information (Thiyagu, 2013; Dunser et al., 2012). According to Thiyagu (2013), Dunser et al., (2012) and Gilakjani (2012), the advent of computer technologies has changed the educators' teaching as well as the students' learning processes. In contrast to the traditional teaching method, the communication of information can be presented in a more innovative manner. The multimedia application offers a new insight into the learning process of the designer and forces learners (students) to represent information and knowledge in a new and innovative way (Rasalingam et al.,2014; Sachou, 2013). Moreover, the communication of the information can be in a more appropriate and effective through the use of the interactive MM elements and the materials can be delivered to students (learner) via three modes namely; teacher-centered mode, student-centered mode and mixed mode.

The teacher-centered mode can be applied when the teacher uses the interactive MM modules to conduct a learning process. Meanwhile, when the student uses the modules as the supplementary tool in the learning process, it is considered as student-centered mode. Finally, the mixed-mode is considered as the best approach whereby the modules used by both teachers and students to deliver knowledge and to increase their understanding of a subject. Figure 2.4 illustrates the three teaching and learning modes of the MM technology-enhanced instructional communication process (Mohd Fitri, 2012).

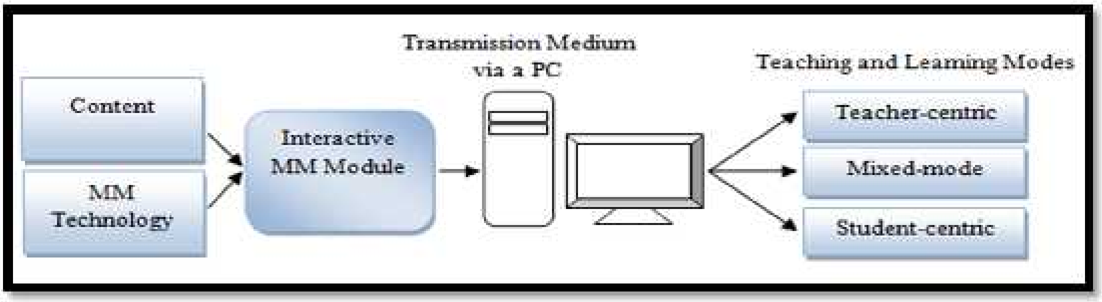


Figure 2.4. The MM technology-enhanced instructional communication process (Mohd Fitri, 2012)

2.7.2 Implication of technology and learning to this study

This section discusses on the teaching and learning approaches which have led to a big impact on the students' learning process. Based on the comparison between the traditional and the technology-enhanced learning processes, the following sub-sections highlight the importance of the technology in learning in this study.

2.8 Motivation

Based on Kleinginna, & Kleinginna (1981) as cited by Di Serio, Ibanez & Kloos, (2013) claims that motivation does not have a standard definition and commonly adopted Houssave cited by Vianin, 2006 (Di Serio et al., 2013) for the educational researches. Houssave claims that Motivation as “the force that initiates and directs behavior” cited by Vianin, 2006 (Di Serio et al., 2013). Motivation is the fuel for human to continuously move and perform an activity and stay connected with it (Dermitzaki et al., 2012; Rost, 2010 cited by Di Serio et al., 2013). Besides that, based on Jeamu, Kim & Lee (2008), lack of Motivation can initiate to major hurdles that averts the success. From previous studies, researchers have recognized the importance of motivation for supporting students in learning. As shown in Table 2.5, motivation is the reason that causes some behavior (Sevinc, Ozmen, & Yigit, 2011; Guay et al., 2010, Brophy, 2004 as cited by Sevinc et al., 2011, Ainley, 2004 as cited by Sevinc et al., 2011; Broussard & Garrison, 2004; Deci & Ryan, 2002). Cultivating science literacy among future generations and professionals through enhancing their science learning motivation is an eventful goal of education (Dermitzaki et al., 2012). In a learning environment, motivation deals with the problem of setting up conditions so that the learners will perform the best of their abilities in academic. Currently, the views of learning not only highlight the cognition but also students' motivation and volition are among the crucial factors for successful learning and achievement (Dermitzaki et al., 2012; Rost, 2010 cited by Di Serio et al., 2013). In short, motivation is concerned with the factors that stimulate or inhibit the desire to engage in behavior. There are two types of motivations that have been widely used in educational practices; Intrinsic Motivation and Extrinsic Motivation (Ryan & Deci, 2000).

Table 2.5

Definitions for Motivation

First Author	Year	Definitions for Motivation
Sevinc	2011	A factor which leads to behaviour and determine the directions, the force and insistence of it.
Guay	2010	Defined Motivation as the reason underlying behaviour.
Brophy	2004	Theoretical concept that is used to explain beginning, direction, force and insistence of goal-oriented behaviour.
Ainley	2004	Motivation is a "energy", direction, the reason for our behaviour and "What" and "Why" we do.
Broussard	2004	Motivation as an attribute that moves us to do or not to do something.
Ryan	2000	To be moved to do something.

2.8.1 Intrinsic Motivation in Science Learning

An intrinsic motivation refers to an activity which is done for an individual's own sake due to own satisfaction and interest. An activity which is done for its inherent satisfaction rather than for some separable consequence is considered as intrinsic motivation (Ryan & Deci, 2000). Previous studies have identified four main individual factors which influence intrinsic motivation namely; challenge, curiosity, control and fantasy. Intrinsic motivation is considered prominent in constructing and reflecting the natural human tendency in learning. Previous studies have shown that there is some strong bonding between intrinsic motivation and academic achievement (Perez-Lopez & Contero, 2013; Lepper, Corpus, & Iyengar, 2005; Cordova & Lepper, 1996). When intrinsically motivated, a person is moved to act for the novelty, fun or challenge entailed rather than because of external products, pressures, or rewards (Ryan & Deci, 2000). In a learning environment, an intrinsic motivation is very salient to boost up the students' level of confident on what they are listening to and learning. So that, through intrinsic motivation, the positive behaviour towards learning and the enjoyment of performing a task especially in a science subject remain for a long term or forever.

2.8.2 Extrinsic Motivation in Science Learning

An extrinsic motivation is an activity to obtain an external goal and this is totally contradicted to intrinsic motivation. The extrinsic motivation refers to an activity simply for some separable consequences such as a verbal reward (Ryan & Deci, 2000), punishment (Tohidi & Jabbari, 2012) and compulsion (Tohidi & Jabbari, 2012). According to Ryan & Deci (2000), extrinsic motivation can make someone to perform an action in hostility and disinterest condition. They would not have an interest or willingness from the bottom of their heart in performing an action. This would affect the performance achievement which could have been better if they perform it with their inner acceptance (Ryan & Deci, 2000). Besides that, students also sometimes should, be extrinsically motivated to cultivate the interest because students cannot be always intrinsically motivated (Tohidi & Jabbari, 2012) but it cannot be on a regular basis to motivate students to perform an action. Furthermore, extrinsic motivation only leads to exam oriented learning where the goal is to obtain a high score. The knowledge of this type of learning is only sustained for a short term and does not provide any experience or skill which can be implemented in their future life.

2.9 Model of Motivation in Learning

Motivation plays an important role in a learning process and precondition for victory (Balog & Pribeanu, 2010). The purpose is to comprise MM in learning is to encourage and generate positive impacts towards learning. Researchers suggested that in a learning process, the students' motivation is more likely to increase when the contents are attracting the students' attention (Phon et al., 2014).

2.9.1 ARCS Model of Motivation in Learning

Researchers applied some theories and concepts that are found to be effective in enhancing the learning process (Huang, Diefes-Dux, & Imbrie, 2006). Moreover, the current studies which are related to learning and motivation. In this study, the famous motivation model ARCS Model by Keller (1983) have been applied. The motivation model was used to simplify their understanding instead of applying the theories directly (Hu, 2008). The ARCS model of motivation comprises four factors which are Attention, Relevance, Confidence and Satisfaction (ARCS). Firstly, the Attention factor refers to gaining the student's attention and maintains their engagement in science (Keller, 2008). Secondly, the Relevance factor relates to the students' experiences and needs (Keller, 2008). Thirdly, the Confidence factor incorporates students' feelings and expectancy for success (Keller, 2008). Finally, the Satisfaction factor includes strategies that help the learners to establish positive feelings about their learning experiences and build the student's sense of reward and achievement (Keller, 2008). The ARCS Model is the most widely accepted sets of models to be used in the learning field (Mahadzir & Phung, 2013; Hu, 2008; Huang et al., 2006). It provides the motivational design, the development and evaluation strategies that have been adapted in a variety of computer-based learning materials and instructional technologies.

Several researchers have conducted studies to investigate the effectiveness of the ARCS model in different learning platforms. Feng & Tuan (2005) found that the ARCS Motivation Theory improves the students' level of motivation. Furthermore, to escalate student's commitment towards learning process it is very salient to have motivation in learning (Feng & Tuan, 2005). The motivation provides students the ability and skill to carry on their future undertakings confidently without any hesitation (Feng & Tuan, 2005). Thus, in a learning process, motivation and curiosity (Feng & Tuan, 2005) are very crucial in engaging learners with a subject matter and to continue their learning process. Table 2.6 describes the ARCS model factors and strategies in increasing student's motivational level (Huang et al., 2006).

Table 2.6

ARCS Model Factors and Strategies (Huang et al., 2006)

Factor	Description	Strategies
Attention	Student's attention and curiosity need to be aroused and sustained	***Perceptual Arousal***: Using novel, surprising, incongruous events to gain and maintain the student's attention level. ***Inquiry Arousal***: Stimulating information seeking by questioning the students. ***Variability***: Providing varieties in elements to maintain students' motivation.
Relevance	Accomplishing the goals of learning	**Familiarity**: Facilitate the language and provide related examples. ***Goal Orientation***: Provide statements or examples that are related to the objectives and goals. ***Motivational Strategies***: Arranging the learning strategies related to the student's motive.
Confidence	Students need to feel the confidence, enjoy and success after completing the tasks	***Learning Requirement***: Provide students the probability of success by presenting performance requirements or evaluations. ***Success Opportunities***: Provide challenge levels that allow meaningful success experience under both learning and performance conditions. ***Personal Control***: Provide feedbacks in supporting the success.
Satisfaction	Satisfaction comes when students are allowed to practice by using the new knowledge which then leads to positive outcomes to the attitudes.	***Natural Consequences***: Provide opportunities to use new knowledge. ***Positive Consequences***: Provide feedback and reinforcements that will sustain the desired behavior. ***Equity***: Maintaining the consistent standards and consequences for task accomplishment.

2.9.2 The Implications of Motivation Theories in Science Learning

As discussed above, there are plenty of advantages of intrinsic motivation theory in the educational field. Moreover, intrinsic motivation describes the motivation, fun and enjoyment in performing a task. For instance, when a student is performing a task, he/she should realize the excess of the task for his/her own sake and perform but not complete the task for a compulsory sake (Deci & Ryan, 2008). Understanding the dynamics of intrinsic motivation in students is the focus of much motivational research over the last several decades. In addition, for an effective learning, there must be a good interaction between teachers and students. A good interaction will make it easier to present the material to the students (receiver) and also to receive the knowledge from the teacher (sender). Intrinsic motivation in education may help the students to have positive attitudes towards science learning in the class and encourage the students to pursue science based career in the future.

This study implemented the MM technology through the eSTAR prototype in order to boost the students' intrinsic motivation level. The increase in intrinsic motivation among the students may change their attitudes towards science learning. The eSTAR provides a more comprehensive science learning materials for the students which utilizes all the multimedia elements so that it is interactive in nature. Apart from that, the intrinsic motivation which motivates the students to do some activities naturally, will create a long term effect in their life but extrinsic motivation affects just for a short time because they only perform whenever they can have something like rewards.

2.10 Augmented Reality (AR)

AR refers to a simple fusion of real and virtual worlds. The word “augment” referring to an action that escalates something in order to make it more substantial. AR follows the earlier term virtual reality, popularized in the 80’s by Jaron Lanier, an early pioneer in the field. Then, in the 90’s, Thomas Caudell, at that time a senior principal scientist in the computer services division of Boeing was involved with some of the first attempt to apply virtual reality technology to Boeing's manufacturing and engineering processes. AR is a technology which allows computer generated virtual imagery to exactly overlay physical objects in real time (Diegmann et al., 2015; Solak, & Cakir, 2015; Radu, 2014; Zhou, Duh, & Billinghurst, 2008). AR is a platform that generates a coalition of real world environment scene and virtual world environment scene produced by the computer that augments the scenes with additional information materials such as text, images, audio, video and graphics based on the real world perception (Diegmann et al., 2015; Solak, & Cakir, 2015; Radu, 2014; Yuen, Yaoyuneyong, & Johnson, 2011). Through the use of AR, the computer can generate an environment which is similar to the real world environment. Based on Azuma (1997) three things that must be considered while developing the AR based projects are namely; the combination of real and virtual world, interactivity in real time and registered in 3D. AR has been widely utilized in the education field (Radu, 2014; Lee, 2012; Luckin & Fraser, 2011; Juan, Beatrice, & Cano, 2008; Kerawalla et al., 2006). AR also has been applied in other domains such as the military; medicine; engineering design; robotic; telerobotic; manufacturing, maintenance and repair applications; consumer design; learning; entertainment; edutainment and psychological treatment domains (Yen, Tsai, & Wu, 2013; Deci & Ryan, 2008; Azuma, Baillot, Behringer, & Feiner, 2001; Azuma, 1997).

2.10.1 Features of AR Books

In developing the AR book, there are many features that have been applied by previous researchers. The applied features in previous AR Books classified according to the MM elements which include; text, audio, video, graphic, animation and also 3D model as shown in Table 2.7. Text, audio, video, graphic, and animation are five MM elements which are able to provide useful and multi-sensory learning experience. Additionally, a 3D model also delivers an in depth and an interactive learning experience. Many researchers have conducted plenty of research on implementing the MM elements, 3D models and the AR technology in educational books. The aim of this review is to identify the most popular features which have been used in AR Books. Furthermore, each feature has its own unique characteristic which is able to provide attractive and interactive learning experience.

All the features of the content somehow have been implemented in the AR books. 3D models are the most popular feature which was utilized in 23 previous AR projects from the several identified AR projects as shown in Table 2.7. Followed by graphics used in 17 AR projects, animation was used in 13 AR projects, text was proposed in 12 AR projects, audio was in 9 AR projects and the least popular is the video which was used in 6 previous AR projects. 3D model is the most used feature in most of the reviewed articles related to AR Books. This feature has spectacular criteria which delivers attractive and interactive learning. Furthermore, an interactive learning environment with 3D models comprised of animated content is capable to convert a passive learning environment into an active learning environment (Moore, Fowler, & Watson, 2007; Dufresne, Gerace, Leonard, Mestre, & Wenk, 1996). Moreover, the implementation of this feature provides an engaged and knowledgeable learning (Thiyagu, 2013: Sachou, 2013; Gilakjani, 2012).

Table 2.7

Features of AR Books

First Author	**year**	**Content Features of AR Book**						**Name of the AR Book**
		Text	**Audio**	**Video**	**Graphic**	**Animation**	**3D Model**	
Abhishekh	2013					*	*	AR Book
Mahadzir	2013	*	*		*	*		Pop-up Book
Rambli	2013					*	*	Alphabet Book
Dunser	2012					*	*	Physics Book
Matcha	2012	*			*		*	AR Book
Rambli	2012	*	*			*	*	Storybook
Setozaki	2012			*			*	Astronomy Textbook
Clark	2012				*		*	Colouring Book
McGrath	2011						*	Ethnobotany Workbook
Margetis	2011	*						SESIL AR Book
Simeone	2011				*		*	REFF Book
Vate-U-Lan	2011	*	*		*	*		3D Pop-Up Book
Ha	2011	*		*	*		*	Digilog Book
Choi	2010	*		*	*		*	Digilog Book
Martin	2010						*	AR-Dehaes
Sin	2010	*		*	*		*	Live Solar System(LSS)
Dias	2009	*	*		*		*	miBook
Chan	2009		*	*	*	*		Not Mentioned
Yusoff	2009		*				*	MRTE Book
Zainuddin	2009	*			*		*	AR SiD
Grasset	2008		*			*	*	Mixed-Reality Book
Scherrer	2008				*	*		Haunted Book
Dunser	2007	*	*	*	*	*	*	AR-Jam
Taketa	2007				*	*	*	Virtual Pop-up Book
Chen	2006						*	Protein Magic Book
Ucelli	2005			*	*		*	Book of Colours
McKenzie	2003					*	*	Eye Magic Book
Back	2001	*	*		*			SIT Book
Billinghurst	2001	*			*	*	*	Magic Book
		13	**9**	**7**	**17**	**13**	**23**	

Additionally, the audio integration in the AR books assists low ability readers to understand the content (Dunser, 2008; Dunser & Hornecker, 2007). According to Laird and Schleger (1985), the majority of the knowledge is gained through seeing (75%), listening (13%) and other senses (12%). Other than that, learning is a prominent process and it would be more effective and long lasting if certain senses, such hearing, sight, touch and emotions are involved in a learning process (Phon et al., 2014; Ha, Lee, & Woo 2011). This is in line with the implementation of features such 3D models, animation, graphics and audio display in an AR book. Moreover, the potential of the AR technology in extracting the real and virtual environment make the learning more powerful. The AR technology is accepted as futuristic technology (Vate-U-Lan, 2011) and it has the potential to change the learning process by incorporating it into the existing textbooks.

Furthermore, the AR content can be viewed in various ways, such as the head-Mounted Display (HMD) and the AR markers (Yuen et al., 2011). The HMD (see Figure 2.5a) is worn like a visor and covers the eyes. A user can see the blended environment which consists of the digital content and also the real environment via an attached camera on the HMD screen (Yuen et al., 2011). Another AR viewing technique is through the use of markers (Figure 2.5b). Whenever, the marker is held in front of a webcam and the AR application which consists of the digital content superimposed on the real environment can be viewed through devices such as a monitor, shutter glass and mobile devices. The digital content moves and rotates whenever the user moves or rotates the marker (Yuen et al., 2011). AR and virtual reality (VR) have quite similar attributes. Both AR and VR are interactive, immersive and information sensitive, but VR completely tied its users to virtual worlds and the user will be disconnected from the real world.

Figure 2.5a. Head-mounted display (HMD)

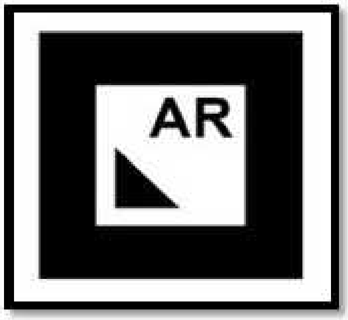


Figure 2.5b. AR Marker

2.10.2 AR and Science Learning

Researchers have suggested that the AR technology is suitable to be implemented in teaching and learning (Solak, & Cakir, 2015; Radu, 2014; Dalgarno & Lee, 2010; Dunleavy, Dede, & Mitchell, 2009; Kye & Kim, 2008 as cited by Di Serio et al, 2013; Bower, 2008 as cited by Di Serio et al, 2013) and also been tested in a real classroom environment (Cuendet, Bonnard, Do-Lenh, & Dillenbourg, 2013; Lee, 2012; Kerawalla et al., 2006). According to Solak, & Cakir (2015) and Lee (2012), AR has made a positive impact among the students in term of performing an effective in-class assessment. Apart from that, AR successfully combined the education and entertainment activities together, which motivate the students to perform well (Solak, & Cakir, 2015; Lee, 2012). AR offers the first-hand real experience in science (McGrath, Craig, Bock, & Rocha, 2011; Chen, 2006; Kerawalla et al., 2006; Shelton & Hedley, 2002) which cannot be experienced through the traditional teaching and learning method (Cuendet et al., 2013; Kerawalla et al., 2006). Thus, the AR markers were created so that they can be used to present 3D models to the students because AR has the capability to make the users engaged in discovering the resources and apply it in the real world that have never been implemented before (Kerawalla et al., 2006). AR has been proven to have the ultimate potential in providing a better and effective learning experience to students in the classroom (Solak, & Cakir, 2015; Radu, 2014; Cuendet et al., 2013; Johnson, Levine, Smith, & Stone, 2010; Kerawalla et al., 2006).

Many professionals and researchers have suggested to applying AR to education domain, especially in the subjects like Chemistry (Chen, 2006; Núñez, Quiros, Núñez, Carda, & Camahort, 2008; Fjeld & Voegtli, 2002), Physics (Chae & Ko, 2008; Buchanan et al., 2008; Enyedy, Danish, Delacruz, & Kumar, 2012; Andujar, Mejias, & Marquez, 2011) and Astronomy (Sin & Zaman, 2009; Shelton & Hedley, 2002). Since, AR is very useful for science domain; it can be implemented in the form of markers which will be pasted on the pages of the science textbooks. It seems like a normal book, but in the pages are markers, when the system recognizes a marker, the digital contents consisting of multimedia elements to make the students able to visualize and understand simple to complex science concepts. Students are able to interact with the digital contents, especially the 3D models by manipulating the markers. The virtual content is able to change the position, shape, and other graphical features of virtual objects with interaction techniques augmented reality supports. Furthermore, by using fingers or the motions of handheld devices such as shake and tilt we have an ability to manipulate virtual objects, as well as to physical objects in the real world (Billinghurst, Kato, & Poupyrev, 2001). The information conveyed by the virtual objects helps user's present real world tasks. The tangible interface metaphor is one of the important ways to improve learning. These augmented reality applications are more similar to natural face-to-face collaboration than to screen based collaboration (Chen, 2006).

2.10.3 Previous studies related to AR Book and Science Learning

With the capability of infusing digital information throughout the real world, the AR technology could engage learners in an immersive context along with authentic experiences to make scientific investigations, collect data outside the classroom, interact with an avatar, or communicate with peers (Dunleavy et al., 2009). Therefore, it may suggest that researchers should pay attention to how the AR technology could further support science learning. There are plenty of AR Books but none for AR textbook in Malaysia. Those AR Books are named as Magic Book (Billinghurst et al., 2001); Interactive AR Book (Clark & Dunser, 2012; Dunser, 2008; Grasset, Dunser, Seichter & Billinghurst, 2007), Augmented Book (Martin-Gutierrez, Saorin, Contero, Alcaniz, Perez-Lopez, & Ortega, 2010; Yang, Cho, Soh, Jung, & Lee, 2009), Pop-Up Book (Vate-U-Lan, 2011), and Mixed Reality Book (Grasset, Dunser, & Billinghurst, 2008). Besides that, the Institute of Multimedia Education in Japan has developed the first AR textbook for mathematics instructional material and a museum display system (Kondo, 2006). Besides that, there are plenty of AR books, but only few AR Science books that have been developed as standalone (computer application) enhanced book. Table 2.8 depicts an example of previous AR Science books which are similar to the eSTAR characteristics such content related to science and only require web camera and PC for learning.

Table 2.8

Example of Previous AR Science Books

Num.	First Author	Year	Subject & AR Apps	Devices	Target User
1.	Dunser	2012	Physics (AR Book)	Web camera & PC	Secondary school students
2.	McGrath	2011	Science (AR Magic Workbook)	Web camera & PC	High School Students
3.	Sin	2010	Science (Live Solar System)	Web camera & PC	Secondary school students
4.	Martin	2010	Physics (AR-Dehaes)	Web camera & PC	University students
5.	Zainuddin	2009	Science (AR-SiD)	Web camera & PC	Deaf students

2.11 Problem Domain Area

In this study the main issue is regarding the deterioration in enrolling into science by youngsters in Malaysia. Based on the literature, the lack of motivation acknowledged as the root for the downward trend in science. The following sub-section discusses on the importance of science for youngsters and students and also previous studies related to the implementation of AR in science learning.

2.11.1 Science in Malaysia

Science is very important in everyday's life on this planet. There are plenty of definitions of science. Science originates from a Latin word "Scientia" and the meaning "knowledge" (Shuell, 1997). Richard P. Feynman quoted Science as "A way not fooling yourself". Moreover, science is the universal inventor and the entire planet connected to science as human need oxygen to stay alive. Besides that, not only scientist related to science perhaps engineers, academicians, doctors, business sectors also connected to the scientific domain. Apart from that, psychological science is defined as the science that deals with mental process and human behaviour (Shuell, 1997).

In Malaysia science is categorized as a core subject in both primary and secondary schools. Furthermore, in Malaysia, there are four levels of education system namely; pre-school, primary, secondary, and post-secondary which includes pre-U, foundation, undergraduate and postgraduate programs under the purview of the Ministry of Education (MoE). Besides that, the science knowledge provides students with the knowledge and skills, especially in developing the thinking and writing skills (Tuan, Chin, & Shieh, 2005; Bonwell & Eison, 1991). Apart from that, science plays a vital role in Malaysia's Vision 2020 in becoming a developed nation by the year 2020. As such this makes science as an important subject to excel in (Talib et al., 2009).

2.11.2 Challenges in Science

There are plenty of researches that have been conducted by the academicians to identify the root of the existing problem in science teaching and learning in Malaysia (Sung et al., 2013; Phang et al., 2012; Aziz et al., 2011; Osman et al., 2006; Norjihan et al., 2006). Basically, there are few challenges and issues faced by teachers and students in a real classroom environment. In a classroom, the teacher depends on the science textbook content and the syllabus as the primary source in conducting the teaching and learning processes (Norjihan et al., 2006). Then, the conventional method of teaching influenced the students and ending up with misconceptions that learning is difficult especially in science learning (Osman et al., 2006; Norjihan et al., 2006). The science textbook is in the form of printed papers with texts and images and it is the main source of reference for the teachers and students. Besides that, supplementary reference books are also available for them. The teaching and learning process takes place in the class where the teacher teaches their students using “chalk and talk” technique, whiteboard and slide or video presentations which are categorized as an obsolete method of teaching (Huda Wahida, 2013; Tan et al., 2008; Norjihan et al., 2006). Meanwhile, a teacher is also required to cover all the required topics for the day within the limited time. So, the opportunity for the teacher to fully interact with the students is limited. So, the students did not have the chance to perform and voice out their opinions or doubts in the classroom (Ibrahim, Surif, & Arshad, 2006). Apart from that, Osman et al., (2006) claim that most of the science teaching teachers are not from a science background. Thus, they are facing difficulties in setting up strategies to teach science (Osman et al., 2006). This leads to the misconception that science is the most difficult subject to understand (Norjihan et al., 2006 & Osman et al., 2006).

2.11.3 Previous implementation of AR Science in Malaysia

As discussed above, AR is the most promising technology and able to display virtual and real environment on computer screen. There are several studies have been conducted to implement the AR technology in science subject in Malaysia (Phon et al., 2014; Rasalingam et al., 2014; Huda Wahida, 2013; Matcha & Rambli, 2012; Abas & Zaman, 2011; Norjihan et al., 2006). There are several AR applications namely the AR-Book (Matcha & Rambli, 2012); the AR Baca-pulih (Abas & Zaman, 2011); the AR Storybook (Rambli et al., 2012); the MRTE Book (Yusoff &

Zaman, 2009). Meanwhile, Sin & Zaman (2010) developed the Live Solar System (LSS) to assist secondary school students in learning Astronomy and the AR-Sid for the primary school deaf students (Zainuddin, Zaman, & Ahmad, 2009) which are related to science.

2.11.3.1 AR-Book

The AR Book was developed to support the Computer-Support Collaborative Learning (CSCL) in order to enhance the teaching and learning method. The measurements such as social interact, Communication and Engagement were implemented to determine the potential of CSCL based learning (Matcha & Rambli, 2012). AR was included in this collaborative learning to enhance the effectiveness of the learning process (Matcha & Rambli, 2012).

2.11.3.2 AR Baca-pulih

This AR storybook (AR Baca-pulih) was developed for the remedial students who have difficulties in reading (Abas & Zaman, 2011). Thus, visual learning concept was applied to ensure the effectiveness of the AR-storybook reached the students (Abas & Zaman, 2011).It is aimed to provide motivation, engagement and enjoyable experience to the students (Abas & Zaman, 2011).

2.11.3.3 AR Storybook

This AR-Storybook was developed based on AR and an old folklore story named as Sang Kancil and the Crocodiles using virtual objects such as 3D models, animation, text and audio (Rambli et al., 2012). The purpose of this AR Storybook is to grab the children's attention and enhance the students' participation (Rambli et al., 2012).

2.11.3.4 MRTE Book

The book was developed to make the user's experience more engaging in the learning process. It is aimed to propose a visualization tool to measure the understanding in science research especially in Tissue Engineering (Yusoff & Zaman, 2009).

2.11.3.5 Live Solar System (LSS)

Researchers have been implementing AR in Astronomy and developed the Live Solar System (LSS) (Sin & Zaman, 2010). This system depicts the relationship between the earth, the sun, the stars and the galaxy through the use of the AR technology. The animation of the virtual content will be displayed by manipulating the cube. It has been proven that the LSS is easy to use and useful in Astronomy learning.

2.11.3.6 AR-SiD

This book was developed based on the visual oriented technique especially for the hearing impaired learners (Zainuddin et al., 2009). This AR book aimed to determine the criteria that should be included when dealing with learners who have hearing impairment. The AR-SiD is useful to visualize the abstract of the microorganism topic where they need to understand the content by only viewing it (Zainuddin et al., 2009).

2.11.4 Implications of Current Science Learning

In a learning process, learners should be active rather than passive (Shank, 2005; Mayer, 2001). Pursuant to Mayer (2001), self-directed learners are often active learners where they seek to learn new information and find ways to put it to use. The importance of new and improved techniques and technologies has over the past few years led to the use of new technologies as learning tools due to the technologies have become a significant part of an individual's life.

The current science learning in schools in Malaysia is wholly dependent on the teacher's knowledge and the learning process and resources that have been utilized lead to passive learning. This means that the teachers have to play the major role in the teaching and learning process and not the students. A good and effective learning process is where the students play the major role and the teachers play a minor role as a guide and this is known as active learning (Thiyagu, 2013; Tuan et al., 2005). Unfortunately, the science learning process in the class is contrary to the teaching methods proposed by the academicians.

2.12 Evaluation

An evaluation is a structured process in determining the useful feedback from the target users of a proposed solution. Through evaluation, the impact level, the usefulness and the benefits of the solution will be investigated (Trochim, 2006). These sub-sections are compressed in order to provide an overview regarding the conducted evaluation in this study. The proper guidelines were referred in this study. There are several tests such as a perception evaluation, the pearson correlation analysis, the regression analysis and the learning performance evaluation were conducted in this study. However, this is the most important phase of this study because this whole study depends on the prototype that is being evaluated and the obtained results from the evaluation.

2.12.1 Heuristic Evaluation

The heuristic evaluation is the most popular of the usability inspection methods. The heuristic evaluation is done as a systematic inspection of a user interface design as well as the content of the prototype. The goal of the heuristic evaluation is to find the usability problems in the design so that they can be attended to as part of an iterative design process. Besides that, through the heuristic evaluation, the content of the prototype can be validated by experts(See Appendix I). The heuristic evaluation involves a small number of evaluators examining the interface (Nielsen, 1995) as well as the content.

The main goal of the heuristic evaluations is to identify the problems which occur with the design of the user interfaces of the prototype and also the content is valid. Usability consultant Jakob Nielsen developed this method based on his experience in the teaching field (Nielsen, 1995). The evaluation involves the experts from the area in a selected study (Davids, Chikte, Grimmer-Somers, & Halperin, 2014). The heuristic evaluation is very useful for the MM application or system development and the evaluation is known as a cost-effective and simple to conduct method (Albion, 1999). Nielsen (1994) created a heuristic list that is commonly used in the heuristic evaluation as shown in Table 2.9.

Table 2.9

Heuristic Evaluation

No.	Heuristic Guidelines
1.	Visibility of system status
2.	Match between system and the real world
3.	User control and freedom
4.	Consistency and standards
5.	Error prevention
6.	Recognition rather than recall
7.	Flexibility and efficiency of use
8.	Aesthetic and minimalist design
9.	Help users recognize, diagnose, and recover from errors
10.	Help and documentation

2.12.2 Perception Evaluation- AR Motivation Questionnaire

The user evaluation is implemented in this study to evaluate the student's perception and learning performance towards the use of the eSTAR prototype. The user evaluation has been divided into two which involves perception study and learning performance study. In the perception study, the students' motivation towards the use of the eSTAR prototype for science learning was determined through a set of questionnaires. The study is extended to determine the correlation and regression between the independent variables (ease of use, engagement, enjoyment and fun) and the dependent variable (motivation) in order to test the hypotheses of this study respectively. Meanwhile, for the learning performance study, the pre-test and post-test assessment is conducted to determine the performance of the students before and after being exposed to the conventional science learning and the eSTAR prototype learning.

A set of questionnaires can be used as a tool to determine user's reaction (Dick & Johnson, 2007) towards the developed prototype based on a conceptual model. An AR motivation questionnaire has been used to evaluate the user's AR experience in science learning (refer Appendix E for the AR motivation questionnaire). Usually, the IMMS questionnaire is being used to evaluate the motivation level from the use of constructed learning material (Huang et al., 2006). The IMMS is based on ARCS motivational design model (Keller, 1993). Besides that, this study intends to evaluate the motivation level through the use of AR technology in Science learning. Therefore, the top five AR motivation measurements (ease of use, engaging, enjoyment and fun) have been identified from the previous literature as shown in Table 2.10. All the measurements are proposed and evaluated by the experts in the field (see Table 2.10). Thus, the aim of this study can be achieved and depicts the level of user's perception towards the eSTAR, whether the applied conceptual model has successfully cultivated motivation in performing well in science and enrolling to higher education and career in science among the students. Related snapshots of this study can be referred in Appendix F.

This study adapted most of the items from the IMMS which have been modified by Huang et al. (2006) and Science Motivation Questionnaire II (SMQII) (Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011) to be used in the evaluation phase. The AR Motivation Questionnaire (see Appendix E) consists of 6 items in the Ease of Use dimension, 4 items in the Engaging dimension, 4 items in the Enjoyment dimension, 4 items in the Fun dimension and 6 items in the Motivation dimension. Among these dimensions, the items for fun is cited from Van Kleef, Noltes, & van der Spoel, 2010; Glynn et al., 2011; Nilsson & Johansson, 2008.

The aim of this evaluation is to determine the user's perception towards the use of the eSTAR prototype which incorporates the AR and multimedia elements such as text, audio, video, graphic and 3D animation as supplementary science learning material. In order to identify the measurements to be included in the AR Motivation Questionnaire, a literature review was conducted specifically to determine the measurements that are commonly used in the implementation of Augmented Reality in learning. There are several AR measurements that have been identified which include; Learnability (Margetis, Koutlemanis, Zabulis, Antona, & Stephanidis, 2011; Yuen et al., 2011 & Wrzesien & Raya, 2010), Task usefulness (Borrero & Marquez, 2012; Yeom, 2011, & Liu et al., 2011), Understanding (Yusoff & Zaman, 2009), Interest (Pérez-López, & Contero, 2013), Yuen et al., 2011), Realistic (Yusoff, Zaman & Ahmad, 2010) and Interactivity (Rambli et al., 2012 & Dunser et al., 2012).

Based on Table 2.10, motivation is the dependent variable of this study proposed by 11 researchers from the total of 35 researchers and the other top 5 AR measurements were implemented as the independent variables in this study. Engaging which is utilized by 16 researchers (Pribeanu, 2014; Rasalingam et al., 2014; Rambli et al., 2012; Abhishek, Reddy, & Kumar, 2013; Dunser et al., 2012; Abas & Zaman, 2011; Vate-U-Lan, 2011; Yuen et al., 2011; Yeom, 2011; Yusoff et al., 2010; Zainuddin et al, 2010; Wrzesien & Raya, 2010; Martín-Gutiérrez et al., 2010; Dede, 2009; Dunser & Hornecker, 2007; Mckenzie & Darnell, 2004 & Billinghurst et al., 2001). Followed by Ease of Use (Pribeanu, 2014; Fleck & Simon, 2013; Davidsson, Johansson, & Lindwall, 2012; Schmalstieg, Langlotz, & Billinghurst, 2011; Kim & Park, 2011; Margetis et al., 2011; Balog & Pribeanu, 2010; Zainuddin, Zaman, &

Ahmad, 2010; Martín-Gutiérrez et al., 2010; Liu et al., 2011; Kerawalla et al., 2006 & Billinghurst et al., 2001).

Table 2.10

Measurements of Augmented Reality

No.	**First Author**	**Year**	**Measurements of Augmented Reality**										
			Ease of use	**Learnability**	**Engaging**	**Understanding**	**Interest**	**Enjoyment**	**Fun**	**Motivation**	**Useful**	**Realistic**	**Interactivity**
1.	Cai	2014						✓					
2.	Ibanez	2014						✓					
3.	Pribeanu	2014			✓			✓					
4.	Rasalingam	2014			✓				✓	✓			
5.	Mahadzir	2013								✓			
6.	Lopez	2013					✓			✓			
7.	Yen	2013								✓			
8.	Fleck	2013	✓							✓			
9.	Rambli	2013							✓				✓
10.	Di Serio	2013								✓			
11.	Wu	2012								✓			
12.	Rambli	2012			✓			✓		✓			
13.	Dunser	2012			✓								✓
14.	Davidsson	2012	✓					✓					
15.	Borrero	2012									✓		
16.	Abas	2011			✓			✓		✓			
17.	Schmalstieg	2011	✓										
18.	Kim	2011	✓										
19.	Simeone	2011						✓					
20.	Margetis	2011	✓	✓									
21.	Vate-U-Lan	2011			✓								
22.	Yuen	2011		✓	✓		✓						
23.	Yeom	2011			✓						✓		
24.	Liu	2011	✓								✓		
25.	Yusoff	2010			✓				✓			✓	
26.	Zainuddin	2010	✓		✓								
27.	Balog	2010	✓					✓					
28.	Wrzesien	2010		✓	✓			✓		✓			
29.	Martin	2010	✓		✓								
30.	Dede	2009			✓								
31.	Yusoff	2009				✓							
32.	Dunser	2007			✓								
33.	Kerawalla	2006	✓										
34.	McKenzie	2004			✓				✓	✓			
35.	Bilinghurst	2001	✓		✓			✓					
			11	**3**	**16**	**1**	**2**	**10**	**4**	**11**	**3**	**1**	**2**

Then, Enjoyment (Pribeanu, 2014; Cai, Wang, & Chiang, 2014; Ibáñez, Di Serio, Villarán, & Kloos, 2014; Rambli et al., 2012; Davidsson et al., 2012; Abas & Zaman, 2011; Simeone, Iaconesi, & Monaco, 2011; Balog, & Pribeanu, 2010; Wrzesien & Raya, 2010; Billinghurst et al., 2001 and finally Fun (Rasalingam et al., 2014; Rambli et al., 2013; Yusoff et al., 2010 and Mckenzie & Darnell, 2004).

2.12.2.1 Ease of Use

In this study, one of the independent variable is the ease of use. The ease of use means the ability to navigate an application or the system without any second person's guidance (Davis, 1989). This was taken into consideration while developing the eSTAR prototype so that it is comprehensive and suitable to school student's computer knowledge. As discussed earlier, transforming the passive learning tradition to the active learning is one of the aims of the AR intervention in Science learning. Thus, the application also should not be complicated and easy to navigate by students without any guidance. Hence, all the virtual contents of eSTAR were standardized for the single AR marker and presented in a simple way.

2.12.2.2 Engaging

Followed by the second independent variable is engaging. According to Table 2.10, engaging is the most stated attribute in previous studies by the researchers for an AR based project. Engaging means fully focused on certain activity and not easily distracted (Arnone et al., 2011). Focusing is a good quality of student, thus they can concentrate on learning in any situation. It has been proven that AR is able to tie up students with the learning process with its extraordinary potential for a long time compared to normal method of learning. According to Phon and Ali (2014), engaging enables the student learning process to be converted into a great learning process.

2.12.2.3 Enjoyment

Enjoyment is a good feeling which able to reduce the tension and boost up the motivation learning process (Van der Heijden, 2003 as cited by Liao, Tsou, & Shu, 2008). Based on the literature, the AR technology is able to provide the feeling of enjoyment in the learning process (Cai et al., 2014; Ibanez et al., 2014; Rambli et al., 2012; Davidsson et al., 2012; Abas & Zaman , 2011; Simeone et al., 2011; Balog & Pribeanu, 2010; Wrzesien & Raya, 2010; Bilinghurst et al., 2001). This assists students to go through the process naturally and not under any compulsion. Enjoyment is defined as the action which makes a person pleasure (Ainley, & Ainley, 2011). This depicts that the intervention of AR in education provides the feel of enjoy to its user. Students are able to feel the enjoyment of navigating the virtual contents of eSTAR.

2.12.2.4 Fun

The fourth independent variable is fun. As shown in Table 2.10, it has been proven that AR technology is fun to use (Rasalingam et al., 2014; Rambli et al., 2013; Yusoff et al., 2010; McKenzie & Darnell 2004). There is a small difference between enjoyment and fun. An enjoyment is something that the user feels while he/she goes through the learning process and fun is when doing some actions such as manipulating the marker. Moreover, the feeling of fun enhances the ability of understanding and knowledge retention (Rambli et al., 2013).

2.12.2.5 Motivation

Motivation is the dependent variable of this study. Previous studies have proven that AR is able to motivate students to be more interested in science learning (Yen et al., 2013). Motivation is an important element in science learning because it leads to conceptual changes, critical thinking and enables students to perform well in the respective subject (Lee, 1989 as cited by Tuan et al., 2005; Garcia & Pintrich, 1992 as cited by Tuan et al., 2005). According to Robert Schuller (1997), “You cannot push anyone up the ladder unless he is willing to climb himself.” Thus, every individual should be intrinsically motivated to achieve their own goal. Thus, motivation is considered very prominent for students to perform well in the learning process especially in science. Students should be academically motivated in order to engage in and invest the effort towards learning and achieving good grades in science.

2.12.3 Correlation Evaluation

The Pearson correlation coefficient (*r*) statistical evaluation is to measure and determine the relationship between the independent variables (ease of use, engaging, enjoyment and fun) and dependent variable (motivation). The value of the correlation coefficient can be measured between +1 and -1 (Pallant, 2013). A +1 value depicts the positive correlation between the variables which is the impact of independent variable and dependent variable in the same direction while the -1 depicts the negative correlation between the variable where the variables are in two different directions (Pallant, 2013). A coefficient zero indicates that there is no relationship between the independent variables and the dependent variable (Pallant, 2013).

2.12.4 Regression Evaluation

The regression analysis intends to determine whether to accept or reject the null hypothesis of this study. Meanwhile, it is to determine the strength of the relationship between the independent variables and the dependent variable. There are two types of regression analysis, namely linear regression and multiple regressions (Pallant, 2013). The linear regression is utilized when there is one independent variable and dependent variable while the multiple regressions are applied when there are more than one independent variable (ease of use, engaging, enjoyment and fun) and one dependent variable (Pallant, 2013). Since this study consists of more than one independent variable (motivation) and one dependent variable, the multiple regressions are applied in this study.

2.12.5 Learning Performance Evaluation-Pre-test and Post-test with the control group

Learning performance evaluated by conducting pre-test and post-test for measuring the knowledge retention. A Pre-test is held before the user exposed to any kind of intervention in a learning process (Dimitrov & Rumrill, 2003). The Post-test is after exposed to the intervention and completes the learning process (Dimitrov & Rumrill, 2003). So, that can identify the effectiveness and usefulness of the eSTAR prototype which is constructed based on eSTAR conceptual model. The same questions are used in both tests in order to determine the user's understanding and knowledge retention before and after the intervention of new material (Dimitrov & Rumrill, 2003). Meanwhile, the questions used for the pre-test and post-test can be referred in Appendix D while the related snapshots can be referred in Appendix G. In addition, there were two groups among students; control group (one group exposes to conventional science textbook) and experimental group (expose to eSTAR prototype) for the science learning. The control group is needed in this study in order to control situations where students with no AR application should only be exposed to science textbook not from secondary supplementary learning materials such magazine, internet sources and etc.

In order to take part in this evaluation, the students were given a consent form to be filled by their parents. However, since some of the students did not return their parent's consent form, only 140 students were able to take part in the user evaluation. The students were divided into two groups based on who have a laptop or notebook at home. Altogether there were 70 students who have laptop or notebook and involved in the user evaluation. Then, a set of 20 multiple questions were distributed among both control group and experimental group of students and they were allocated with 20 minutes to answer all the questions. The selected multiple questions are based on chapter one (The World through Our Senses) and chapter two (Nutrition) from the existing textbook provided by the MoE. The selected questions were proposed by the content expert (teachers) of this study who have more than five years experience in teaching the science subject. After the pre-test, the developed eSTAR prototype was distributed among the experimental group and they were instructed to use the prototype for their in and out class science learning. After one week, the control group and experimental group had the post-test using the same 20 multiple questions which has been used in pre-test. In order to determine the student's motivation using the eSTAR prototype, the AR motivation questionnaires (see Appendix E) were distributed among the experimental group only.

2.12.6 Implication of evaluation of this study

This section discusses regarding conduction an effective evaluation process in this study. Previous researchers have researched all the possible evaluation that can be applied in a technological intervention learning environment. This study conducted the perception study, the correlation analysis, the regression analysis and the learning performance study. The perception study is conducted to determine the user's perception towards the eSTAR prototype that has been developed by referring to the constructed conceptual model. Then, the correlation analysis is to determine the relationship between the independent variables (ease of use, engaging, enjoyment and fun) and dependent variable (motivation) while the regression analysis is to test the hypotheses. The significant or no significant and positive or negative outcomes of the evaluations depict the effectiveness and usefulness of the constructed eSTAR conceptual model.

2.13 Summary

The focus of this chapter is to enhance the understanding regarding the related topics in this study. The multimedia technology, AR, theories, models, principles and problem domain have scrutinized to the overall concept of the eSTAR conceptual model construction. The purpose to construct the eSTAR conceptual model is to utilize as guidance in designing and developing eSTAR prototype. The model comprised with three major components (design for interaction, design for information and design for presentation) and also implemented several theories (intrinsic motivation theory, ARCS, CTML and MM principles) to deliver an effective and useful eSTAR prototype. Finally, a crystal clear explanation regarding the conducted evaluation in this study was discussed.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Overview of Research Methodology

A research is a systematized effort to gain new knowledge. Basically, a diligent search or an investigation of an issue helps to establish facts and reach new conclusions or findings. This chapter comprises of selected research design and its processes in order to achieve the research objectives.

3.2 Research Process

The research process is a journey in order to complete and achieve the research questions and the process in finding the answers is known as the research methodology. The research methodology is the combination of the methods, processes and the tools that are being used in a study (Nunamaker, Chen, & Purdin, 1991).

3.3 Research Methodology

A research methodology is defined as the process to accumulate all the knowledge (Rajasekar, Philominathan, & Chinnathambi, 2006), details for the purpose of research studies. There are many research designs and diagrams that can be used as guidelines for research processes which were contributed by Nunamaker et al., (1991), Purao (2002) and Kuechler & Vaishnavi (2011). Kuechler & Vaishnavi (2011) general research methodology of design as shown in Figure 3.1 has been adapted in this study. This research design is comprised of five steps namely; awareness of a problem, suggestion phase, development phase, evaluation phase and conclusion.

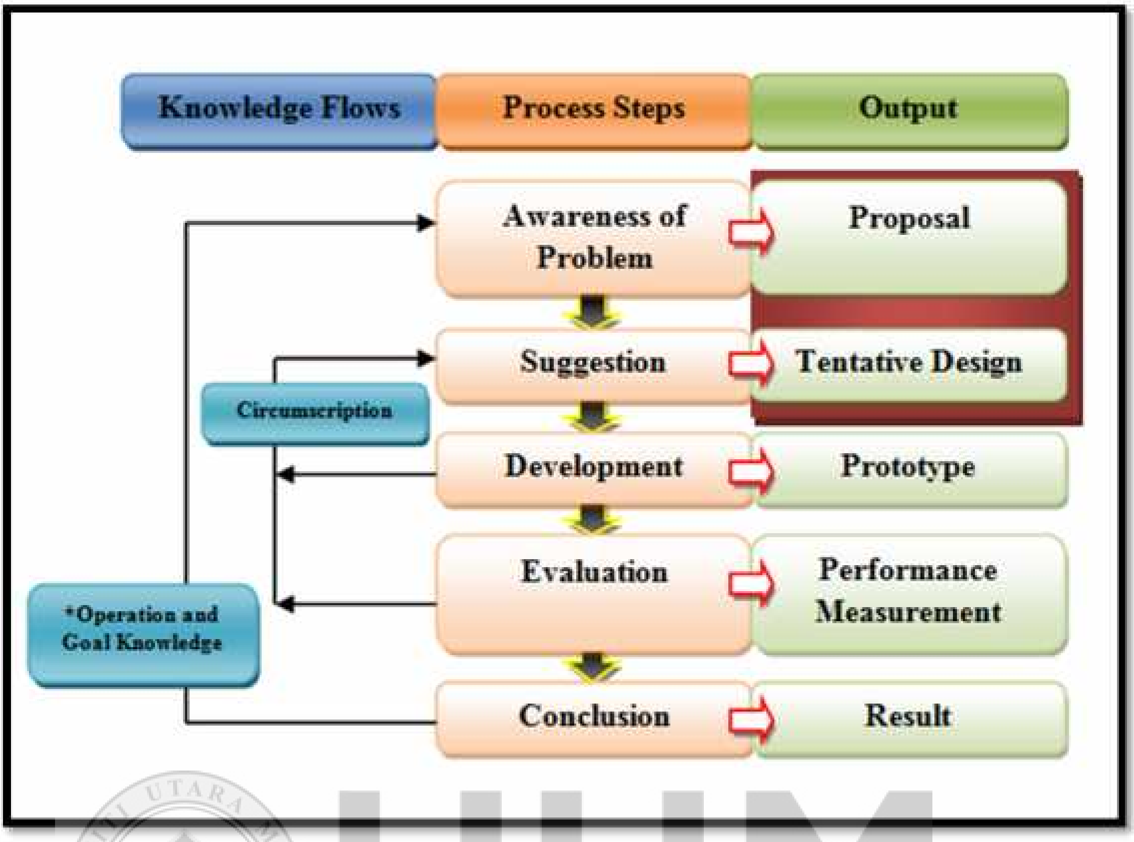


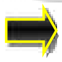
Figure 3.1. Research Methodology of this study (Adapted from by Kuechler & Vaishnavi (2011))

3.4 Methodology of the Study

In motivating students to be more interested in enrolling science-based higher education and professions through the use of the AR technology, this study will adopt a general methodology of design proposed by Kuechler & Vaishnavi (2011). This general methodology of design comprises of five steps which include; awareness of a problem, suggestion, development, evaluation and conclusion. Furthermore, to develop a better and systematic learning material, Instructional System Design (ISD) was adapted as a guideline in the development phase. In spite of using a proven methodology of design by Kuechler & Vaishnavi (2011), ISD was still adopted to provide a set of more dynamic and spectacular guidelines in developing an effective, faultless and impeccable eSTAR prototype. Table 3.1 explains the description of design methodologies and Figure 3.2 depicts the process of the design methodology.

Table 3.1

Design Methodologies Description of this Study

Item	**Description**
Flow of Knowledge	The flow of knowledge is the process in this study.
Process Phases	There are five steps included in this design research phase namely; Awareness of Problem, Suggestion phase, Development Phase, Evaluation Phase and conclusion.
Outputs	Each output is from each process phase in this design research process.
Operation and Goal Knowledge	The goal of the knowledge of the overall research design processes.
Circumscription	The limitation occurs in each process in this study.
	The purpose of Circumscription is to repeat the previous process that happens.
	Each process phase has its own output and this red outlined arrow directs to the outputs.
	This arrow directs to the next process in the design research methodology
	This star indicates continuous processes involved in the each process at each part.

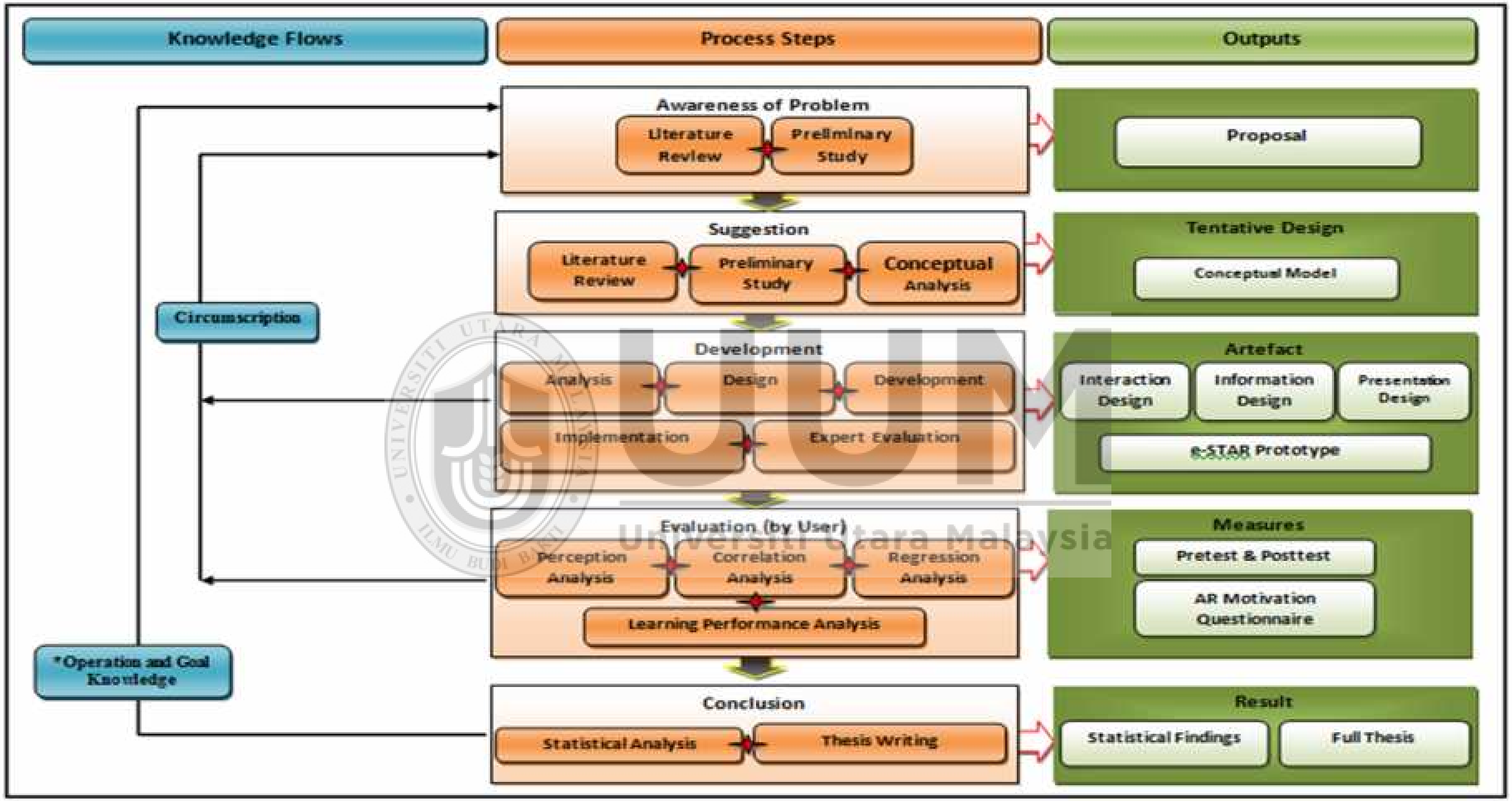


Figure 3.2. Process of research study

3.4.1 Awareness of Problem

Awareness is a state of consciousness and having the knowledge in the selected research area. The knowledge about the respective issue can be gained from multiple sources (Kuechler & Vaishnavi, 2011). It is necessary to keep updating and follow-up the progress with the issue in order to contribute to an effective and dynamic output. In this case, the focused issue is demotivation among students, which leads to lack of interest in science subject and not pursuing their higher education and profession related to science.

Day by day, the motivation towards science subject among students is becoming more alarming and the achievement in the subject is decreasing. Unfortunately, there is a downward trend in enrolling science based higher education and professions due to the lack of motivation. In order to achieve the ultimate goal which is to achieve the status as a developed nation by the year 2020, the younger generation should perform well in school level and enroll science related higher education and profession. As the number of youngsters in science related professions such as scientists, engineers and doctors increases; it will assist in sustaining the economic level in the high position and capable to achieve the goal.

The literature review is the most helpful part in identifying the current state of the research issue. In following up with the current issue, a literature review was conducted to determine the area of study. Besides that, the literature review is prominent to clarify the theories and principles which will be implemented into this study. It is very important for the researcher to stay conscious and follow the progress of science subjects with backup information and knowledge. Apart from that, the researcher should be aware of the current learning environment and the supplementary materials which are being used by students for learning. So, it helps the researcher to contribute something new in enhancing the learning process.

In this case, currently, conventional “chalk and talk” and then extend to whiteboard technique are being used in the teaching process. Additionally, teachers are making use of a Power Point slide presentation, video presentation and laboratory exercises in the classroom to motivate and encourage students to learn and be interested in science (Huda Wahida, 2013; Tan et al., 2008; Norjihan et al., 2006). Nevertheless, students still require a different form of learning environment in order to motivate them especially in science learning. The science subject has complicated theories and terms which are difficult to explain verbally and textually. Furthermore, science is a comprised with dynamic and complicated concepts which is difficult to make understand. Thus, Students face difficulties in understanding several complicated concepts, principles and the meaning of certain scientific terms and processes (Hwang et al., 2012; Aziz et al., 2011). Besides that, students require a new form of learning approach which is interactive and trendy (Rasalingam, 2014; Sachou, 2013; Arnone et al., 2011; Pasaréti, 2011). Thus, eSTAR has been designed and developed to cater the needs of younger generations nowadays in the form of an advanced learning tool to motivate them to be interested in science learning.

3.4.2 Suggestion

After the researcher has the solid evidence and knowledge to step forward with the selected issue, the next phase is the suggestion phase. Awareness of a problem leads a researcher to determine the route for the entire journey of this study and achieve the expected goal. The eSTAR conceptual model constructed as a guideline for designer and developer to develop an effective and useful eSTAR prototype using AR which is a very promising technology. Although, AR is not a new technology to the science and technology world, there is a lack of awareness towards AR's ability in the educational environment. Based on the previous literature, AR is proven to be futuristic and fullest potential medium to convey the learning content effectively to the learner (Lee, 2012). AR also provides the real life experience of learners by presenting the virtual content in a real world environment (Lee, 2012). Moreover, as mentioned in proposal this is a low cost learning process. Students only need the AR markers with the AR application to proceed with this learning.

Basically, the suggestion phase is a creative phase. Creativity is a very important attribute in enhancing the existing learning material or developing an instructional computer based learning material which encourages a learning process (Lee & Boling, 1999). Thus, three prominent elements were referred to in developing a valuable and a potential prototype able to convey the contents and knowledge of the presented learning material in an interesting way as shown in Figure 3.3. The three design guidelines comprising of the design for interaction, the design for information and also the design for presentation.

However, a conceptual model has to be constructed before continuing to the development phase. According to Maxwell (2005), a conceptual model in a research is not only can be referred to the existing model but it can be an owned constructed model. The model's purpose is as a guidance for the rest of the research process.

Apart from that, studying previous work is very useful in gaining more knowledge regarding the research area. Further information about the model will be discussed in the following chapter.

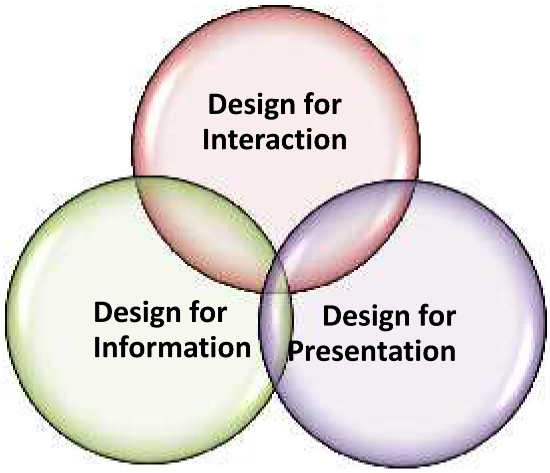


Figure 3.3. Three elements of design guideline

3.4.3 Development

The development phase comes after the suggestion phase. As discussed above, the suggestion phase is a creative part and a lot of knowledge regarding the research issue is needed. In the development phase, a tentative design is implemented. Instructional System Design (ISD) has been introduced to solve human's problems in performance which is related to learning or training. The ISD has been used in military training since 1960's but it has been accepted and implemented in training and education in the 1970's. Furthermore, there are several traditional systematic approaches such as the Performance Based Training (PBT) and the Criterion Referenced Instruction (CRI) that have been applied in learning and training. The ISD models have divided the instructional design process into five phases (Merrienboer, 1997) which include; Analysis, Design, Development, Implementation and Evaluation. In addition, the ISD differs from Instructional

Design (ID) (Merrienboer, 1997). The ID focuses only on the design and the analysis phase while the ISD focuses on the entire process of creating the learning platform (Merrienboer, 1997). Besides that, the ISD is a systematic process used to develop a consistent and effective education program. The systematic ISD processes have some common elements in the descriptions such as analysis, design, development, implementation and evaluation (ADDIE) (Gustafson & Branch, 2007).

The proposed eSTAR prototype has been developed based on the constructed model. Besides that, three elements were adapted for this study which include; design for interaction, design for information and design for presentation. They are considered very prominent especially in developing a computer based learning material and emphasized by the User Centered Design (UCD), the macro design strategy and the micro design strategy. In the development phase, it would be easier if the activities and expectations are defined in detail from the beginning stage of the research study. According to Reigeluth (1996), the macro and micro design strategies are obtained from instructional theories. Figure 3.4 portrays the relationship between the elements and guidelines in this study.

Figure 3.4. Design guidelines in this study

The ADDIE model of instructional design has been used in this study to develop the prototype. The term ‘ADDIE’ stands for Analysis, Design, Development, Implementation and Evaluation. According to Hall & Sanders (1997), this instructional design model is capable to be integrated in any learning strategy. Moreover, ADDIE is a generic model that has a systematic approach and provides with a framework to ensure an effective educational material is generated. Meanwhile, for a comprehensive and perfect development phase, there are three design guidelines included in this methodology process.

The experts in this research study are classified as the content experts and the interface experts. The content expert of this research study is the secondary school teachers who are teaching the science subject. They have been involved in this study since the initial stage of this research. Their involvements are very prominent in order to ensure the validity of the prototype's content. The prototype has been developed based on the advice and suggestions from the content experts. There were two science teachers were appointed as content experts. In the following sub-section, the ADDIE and the three design guidelines are discussed in detail.

3.4.3.1 Analysis

In the Analysis phase, the instructional problems gain complete comprehension knowledge. Moreover, this phase has to be systematic since it becomes guidance to the designer to determine the basis for all future decisions (Gustafson & Branch, 2007). The phase also helps to identify the target users, the limitations and other related elements in the design process. The analysis part identifies the learning problem and sustains the relationship of the user with the developed prototype. It is related to the contents of eSTAR and so as the characteristics and criteria of the target user. Furthermore, it clarifies the objective, the user's needs, the learning environment, material presentation options and also the timeline for the proposed project. Moreover, this part determines the target user's role and their participation with eSTAR. Therefore, an analysis was conducted to relate the role of the user with the prototype and a participation model was developed. The importance of participation map is to determine the role of the user and the artefact. Moreover, a participation map is the simplest and easiest way to model an activity (Chan & Jaafar, 2009).

Based on the Figure 3.5, it illustrates the participation map for the eSTAR prototype. The map shows the students as the user actors since they are representing the target user in this study. The learning is the main activity between the user (student) and task (eSTAR prototype).

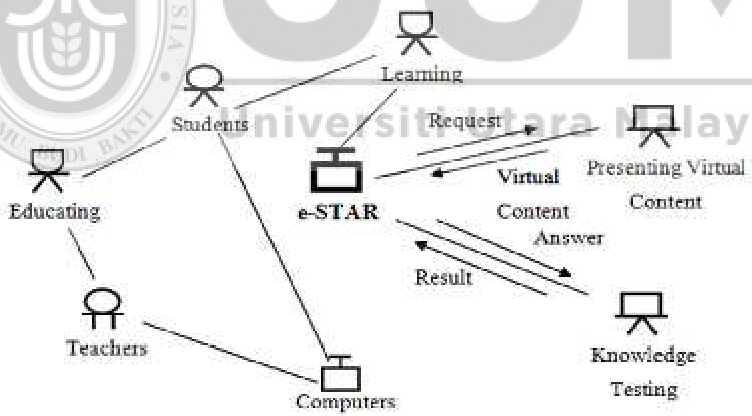
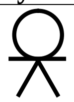
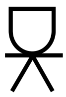
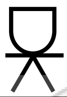
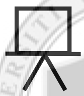
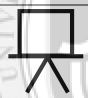
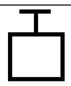
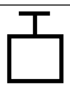


Figure 3.5. Participation map for the eSTAR prototype

The presentation of virtual content and testing are the main activity provided by the eSTAR prototype. Besides that, the user acquired for virtual information using the AR Markers and its presents the virtual content after detects the AR marker. Then, the user tests their knowledge by answering the quiz questions. The teachers as player may use the computer artefact for different applications and activities while the computer as the tool for the activities. Table 3.2 describes each of the notations involved in the participation map.

Table 3.2

UCD Notation Description

Symbol	Name	Description
	Student (User actor)	The students as the user actors who interact with the system of reference.
	Learning	The relationship between the student and the system of reference which is eSTAR.
	Educating	The relationship between the student and the eSTAR which for educating.
	Presenting	The eSTAR presents the contents in interacting with the system of reference.
	Testing	The eSTAR provides testing in interacting with the system of reference.
	Teacher	The teacher as players who don't have interaction with the system of reference.
	eSTAR	The system of reference or artefact employed within the learning activity.
	Computer	The computer plays a role as a medium within the learning activity.

3.4.3.2 Design

The design phase involves activities in which a lot of new ideas for possible development will be discussed and by using the information in the analysis phase a project can be developed. This phase should be specific and detail in producing the storyboard, prototype and design of the user interfaces (Chen, 2008 cited by Nurtihah, 2012). The design part should be logical and each of the instructional design plan must be implemented with care. Moreover, this part is prominent in determining the user's intention when interacting with the application. Figure 3.6 depicts the user actor's (Student's) intention and the responsibilities of the material in a learning process. The right side is the user actor's intention represented by the student while on the left is the responsibilities of the application which is the eSTAR prototype in this study. The application is responsible to provide the output for the input for the user actor as shown in Figure 3.6.

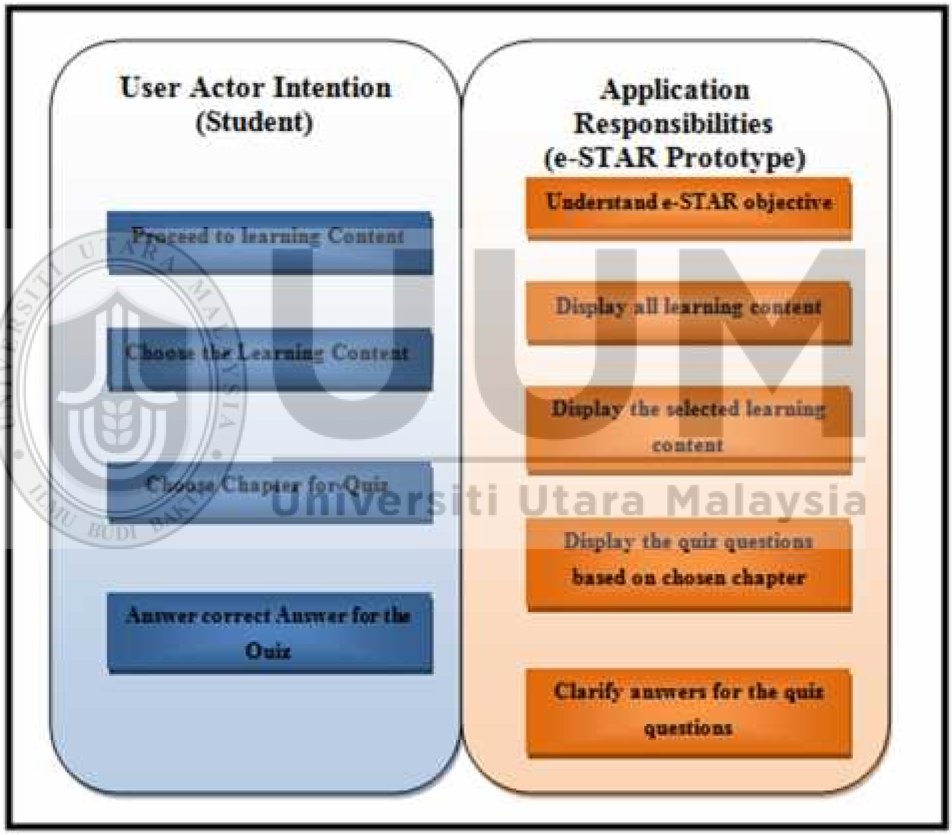


Figure 3.6. Task case of the eSTAR prototype

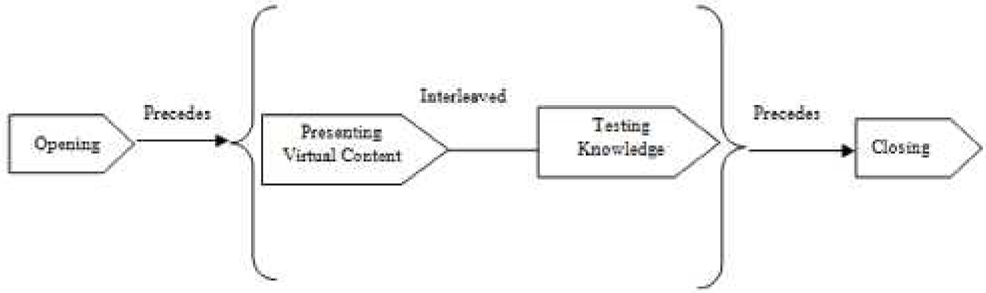


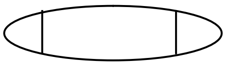
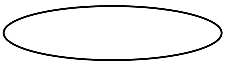
Figure 3.7. Activity map of eSTAR prototype

Furthermore, Figure 3.7 shows the activity map to determine the activities that have been incorporated in the application. Then, construct an activity task model is the next step after developing the activity map model. It is literally similar to information and presentation design which depicts the connection between the activities and task in the eSTAR prototype based on a conceptual model. The ARCS model is applied in this study in order to view the relationship in cultivating motivation towards the learning process. The design of the prototype plays vital role in attracting the user's attention and attract the users' first impression towards eSTAR.

At this stage, the ARCS model is included in order to extract the user actor's (student) intention towards the learning process. Furthermore, the intrinsic motivation theory is also referred to the activities in interaction with the eSTAR prototype. The task and activities are the goal-directed orientations among actors known as "action" and is also described in Table 3.3.

Table 3.3

eSTAR Prototype Activity Task Model

Notation	Description
	Depicts action by an actor or a player for some goal within the activities
	Depicts the action by an actor or a player for some goal within activities
	Depicts the two main activities in the learning process
Interleaved	Discontinuous

The ARCS and intrinsic motivation theory were applied in order to determine the interrelationship in fostering a learning process. This study gives emphasis to the learning through the use of eSTAR. A model has been developed for this stage of this study as shown in Figure 3.8.

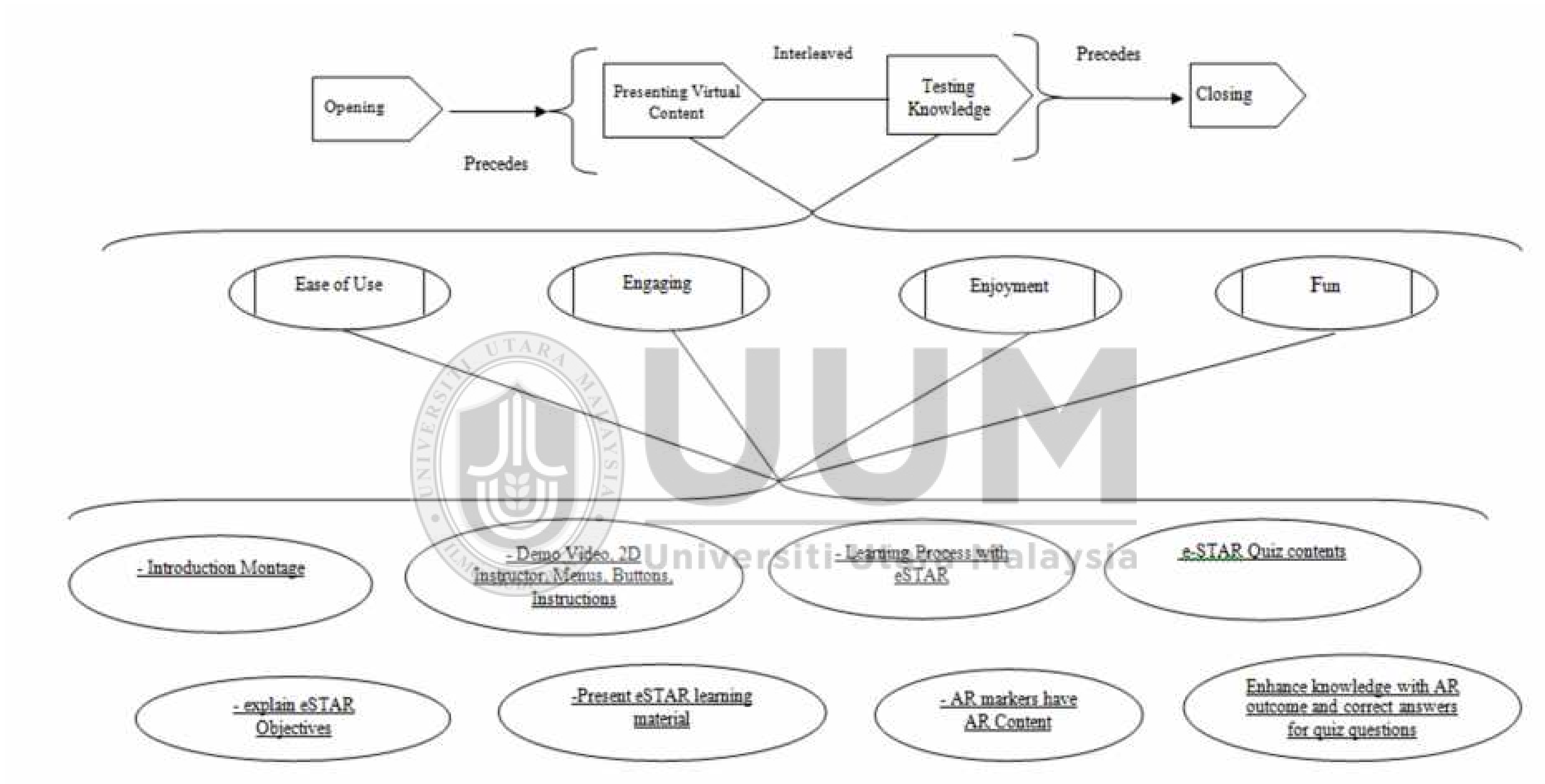


Figure 3.8. Activity task model of eSTAR prototype

3.4.3.3 Development

The third phase in ADDIE cycle is the development phase. This phase needs an additional assistance for managing the technology. The development phase comprises of the initial drafts, reviews and revises of the developed prototype until it functions meet the expectations.

The content of the eSTAR prototype has been developed based on the design phase. In this stage, the researcher developed the storyboards and graphics as guidance throughout the project. In a computer based learning process, the programmer develops or integrates the technologies involved. Besides that, the changes will be made according to the feedback from the target users (form two students). The combination of design guidelines such as the design for UCD, the design for information (macro design strategies) and the design for presentation (micro design strategies) is included in this study as an attempt to develop the eSTAR prototype which is capable of conveying the information as an effective and attractive supplementary learning medium to the users.

The macro design strategies were comprised in the design for information, in order to convey the eSTAR information to the user. Moreover, the macro design strategies with the selection, sequence and organization of the eSTAR contents to be presented and influence the user (Salam, 2010 cited by Nurtihah, 2012). Meanwhile, Fogg (2002) stated that the selection or organization of the MM elements such as texts, images, graphics, audios and animations cultivate a positive impact on users' perception and influence the users' achievement in their performance.

Besides that, the micro design strategies were incorporated in design for presentation. The micro design strategies were used to systematically organized the MM elements and the AR technology in order to motivate learners and cultivate the interest in science learning. Therefore, the design for presenting the content of the eSTAR prototype for a formal learning is very prominent. This is because the first impression of the users towards the prototype determines the entire learning experience of using the eSTAR prototype. Apart from that, to make the presentation more professional and effective, the Cognitive Theory of Multimedia Learning (CTML) and the multimedia learning principles (Mayer, 2001) are used as guidance in this research study.

Furthermore, the combination of three design guidelines (design for interaction, design for information and design for presentation) in this study was an effort to the eSTAR prototype which is able to cultivate the interest and motivate students to continue enrolling for higher education and a career in science. In addition, the each design guideline has comprised with three strategies namely; the Used Centered Design (UCD), the Macro design strategies and the Micro design strategies respectively as depicted by the eSTAR conceptual model. The learning contents of the eSTAR prototype are implemented in information design while the MM principles and the CTML implemented in presentation design. The importances of these strategies are discussed in detail in the following sub-section. For more information regarding the strategies, refer to Chapter Four (Design and Development of eSTAR Prototype).

a. Information Design (Macro Design Strategies)

As discussed earlier, the interaction designs emphasize the relationship between the users and the activity of the eSTAR prototype. Then, the purpose is to scrutinize the learning material in order to deliver useful and correct information. Apart from that, the eSTAR learning material's topics are adapted from the textbook provided by ministry of education and the contents are taken from reliable learning materials and suggested by content experts. In order to cultivate a strong impact among students, the selection of the texts, audio, video was given more priority to obtain a positive learning attitudes and outcomes (Fogg, 2002).

b. Presentation Design (Micro Design Strategies)

In this study, the presentation design adapted the micro design strategies to make sure a high quality of the eSTAR prototype by arranging and organizing the MM elements in an effective manner. Furthermore, in order to achieve the objective, this study included the MM principles and CTML as guidelines which are proposed by Mayer (2001) for the MM presentation.

3.4.3.4 Implementation

In the implementation phase, the designer implements all the elements that have been planned on designing the eSTAR prototype. Moreover, the prototype comprises of virtual contents in the form of texts, images, audios, animations and videos which are coded into a fiducial marker so that the user can view the virtual contents when held in front of the web camera. Besides that, authoring tool plays a vital role in making the design phase, development and implementation processes more comprehensive and successful.

a. Multimedia Development Process (MDP)

MDP is to guide the research in developing the learning platform (Neo & Neo, 2004 cited by Nurtihah, 2012). Basically, the MDP focuses on the operational function of the software. The multimedia developer has to consider the content of the application besides the operational functions. The Authoring process will simplify the production process. There are three phases in MDP namely; Pre-Authoring, Authoring, Post-Authoring as shown in Figure 3.9. MDP was used as guidelines in the prototype implementation phase.

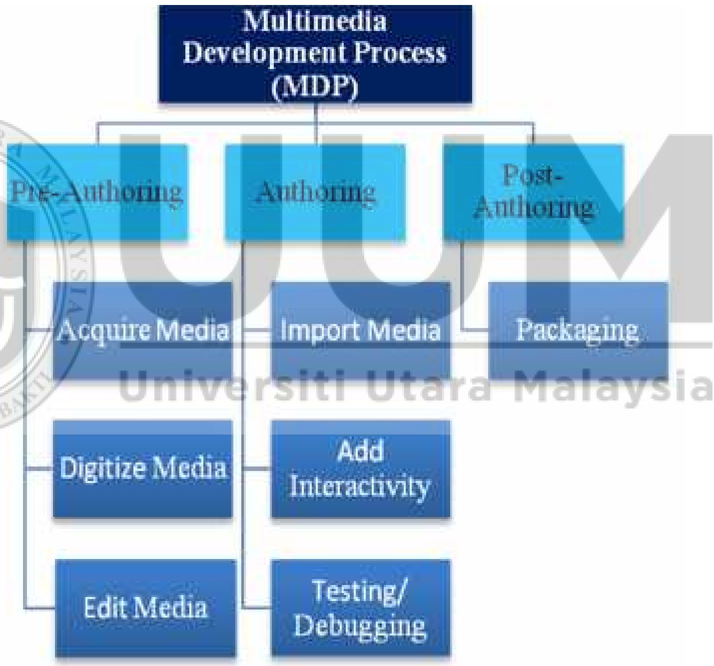


Figure 3.9. The flow of MDP process

i. Pre-Authoring

- **Acquire Media**

The Acquire Media is the first step in pre-authoring phase. In this phase, all the media that are used to deliver the eSTAR content are identified. Moreover, the audio and video sources utilized in order to produce an attractive and comprehensive learning material. Besides that, graphics are used to explain the current circumstances or the concept. The content materials are gathered in digital format. However, the materials in an analogue form like to print texts or images are digitized later.

- **Digitize Media**

In the digitize media phase, all the analogue materials such as printed texts or images are digitized. Here, the texts or images are scanned through a scanner to convert it into the digital form.

- **Edit Media**

All the collected materials are edited in this phase. Some of the digitized materials are enhanced in terms of creativity and special effects to make them more attractive and interesting. The effects, colour changes and other changes can be made on the materials. A proper editing is very important to ensure the edited materials to obtain the desired output and focus.

ii. Authoring

- **Import Media**

In the authoring phase, all the files and materials are digitally stored in the computer and are imported to the authoring tool where all materials and functions are integrated together in the authoring production.

- **Add Interactivity**

Besides that, add interactivity is the last stage in the authoring phase where designers can enhance the product. After this process the prototype is fully developed. All the media that has been created and stored digitally in the computer is brought together as a final presentation. In this stage, all the interactivity and navigation involved will create multi-sensory experience for the users.

- **Testing and Debugging**

Once all the interactivities are incorporated into the prototype, the testing and debugging processes are conducted to troubleshoot any errors in the prototype. Usually the processes will be repeated several times to ensure that the prototype is error free.

iii. Post-Authoring

- **Packaging**

Packaging is the last stage in the post-authoring phase. In this stage, the prototype is completed and ready to be used. Since, the AR technology is implemented in this prototype; it is conveyed through the fiducial marker. After that, the prototype is delivered to two groups; the experts and the users for evaluation. Firstly, the experts evaluated the eSTAR prototype in terms of the contents and the functionality. Comments and feedbacks from the experts were used to modify and enhance the prototype. Secondly, the enhanced prototype was then delivered to the target users for user's evaluation.

b. Related Software

1. Adobe Flash CS 6

The Adobe Flash CS6 was used as a platform for the eSTAR prototype. The Adobe Flash is embedded with an object-oriented language known as the Action Script which integrates the elements in an application. The Adobe Flash is an application for developing rich and comprehensive content, Web applications and user interfaces (Johnson, 2009). It allows developers to integrate with the MM element's texts, audios, graphics and videos to deliver results in e-learning and marketing.

2. Adobe Photoshop CS 6

The Adobe Photoshop CS6 was used to create and edit all the 2D graphics applied in the prototype. According to Shelly & Starks (2010), through the use of Photoshop, all the digital images can be modified with additional effect. Photoshop enables the digital images to be cropped, resized and rotated, brushing, changing the contrast, balancing and combining extra elements to the images to make them look new and attractive. The designer can save an image into a multilayered composite.

3. Adobe Audition CS6

The Adobe Audition CS6 is also known as Cool Edit Pro is an Adobe system's product. The use of this software is to edit sounds. Besides that, the Adobe Premier can be used to record and edit sound. This version is more enhanced in stretching the real time scenes, align the automatic speech, correct a pitch with very detail and support HD video playback. This software adds more effects in this project by producing high quality sound system.

4. Camtasia Studio 7.0

The Camtasia Studio 7.0 is a real time and timeline based video editing application which is used to edit and produce videos. The Camtasia Studio 7.0 supports a high resolution video editing up to 10240 x 8192 resolution which is the maximum sequence frame size. This software integrates with other Adobe's software which helps to enhance the editing processes and produce a high quality video.

5. Autodesk 3Ds Max 2010

The Autodesk 3ds Max known as the 3D Studio Max is an animation, modeling and rendering package developed by the Autodesk Media and Entertainment. This software provides a platform to model the objects and has flexible plug-ins which can be used on the Microsoft Windows operating system. Moreover, the Autodesk 3DS Max is used to develop three dimensional (3D) animated scenes in the eSTAR prototype.

6. BuildAR 2.0

For this study primary consideration is AR in a science subject thus, BuildAR 2.0 is used as a medium for delivering the science content with the addition of MM elements. The BuildAR original developer is the Human Interface Technology Laboratory (HIT Lab), in New Zealand. The ultimate goal of the eSTAR prototype is to enhance user's experience with AR technology. The BuildAR supports the marker based and the markerless based AR projects. It also supports all the MM elements such texts, images (.jpg and .png), audios (.wav), videos (.MP4) and 3D models with animation (.fbx). The only limitation is that the BuildAR 2.0 can only be used to develop a standalone AR computer application for desktop and laptop. Furthermore, this project is intended for students (14 years old) thus easy-to-learn software is crucial and the BuildAR accomplishes those criteria.

3.4.3.5 Experts Evaluation

The Heuristic or expert evaluation is categorized into two namely; content and functionality evaluation and interface evaluation. For the content evaluation, the experts involved are the teachers who are teaching the science subjects in the secondary schools. They are required to validate the contents of the eSTAR prototype to ensure that they are suitable with the Integrated Secondary School Curriculum and suitable for Form 2 secondary school students. For functionality and interface evaluation, the experts involved are lecturers who have experience in teaching and developing Multimedia applications. They are required to use the prototype and identify any problems related to the functionality and interface of the prototype. Through this evaluation, the designers can identify and troubleshoot the problems related to the design of the interface and the prototype functions.

3.4.4 Evaluation by Users

An evaluation is a standardized way to evaluate the concept, design and implementation of a project. After heuristic evaluation (by experts), the prototype was assessed by the target users of eSTAR, who are the form two students. The evaluation by users involves a perception study, a correlation analysis, a regression analysis and learning performance studies. The AR motivation questionnaires are used for the perception study, correlation analysis and regression analysis. Appendix E can be referred for the example of the AR motivation questionnaire. The purpose of conducting the perception study is to determine the perception from the eSTAR prototype users regarding the science learning using AR through the use of the AR motivation questionnaire as shown in Table 3.4. Besides that, the correlation analysis is to determine the potential relationship whether positive related or negatively related between each of the independent variables and the dependent variable. Meanwhile, the regression analysis is to verify the relationship between one dependent variable and one or more independent variables. The purpose of the AR questionnaire is to check whether the eSTAR prototype which is based on the constructed eSTAR conceptual model is capable to motivate students to perform well in science. The questionnaire (See Table 3.4) contains 5 Likert-scale and the respondents rate their responses towards each statement from 1 (Strongly Disagree), 2 (Disagree), 3 (Somewhat Agree), 4 (Agree) and 5 (Strongly Agree). In this study there were 140 secondary school students participated in the evaluation phase. Since, the research intends to compare between science learning using the conventional textbook and the newly developed eSTAR prototype. The total number of students was divided into two groups with 70 students per group and equal number of students categorized into two groups. Whereby, 70 students in the control group with the conventional textbook intervention and another 70 students in the experimental group with the developed eSTAR prototype intervention utilized for their science learning.

Table 3.4

AR Motivation Questionnaire: AR Measurements and Items

AR Measurements	Items
Ease Of Use	eSTAR is easy to use
	eSTAR is suitable to apply in science subject
	eSTAR is suitable to use as revision tool in science subject
	Augmented Reality is suitable for personal use
	The steps to use the eSTAR is easy to remember
	Augmented Reality has make the revision process easy
Engaging	eSTAR attract my interest in studying science for a long time
	eSTAR makes me repeatly revise science subject
	eSTAR makes me involve in science studies for long time
	Augmented Reality increase my involvement in the learning of science
Enjoyment	Really like and enjoy the eSTAR application in the learning of science subject
	eSTAR made deeply enjoyed the uniqueness science
	I enjoy learning science by using the eSTAR
	Augmented Reality cultivates the interest in learning science
Fun	eSTAR is very fun to use in the teaching of science
	Contents of the eSTAR adds fun in learning science
	I enjoyed using the eSTAR as revision tool in science
	eSTAR learning is fun compared with the conventional textbook with normal text
Motivation	eSTAR is really easy to use
	eSTAR increase my involvement in the learning of science
	I enjoyed the process of learning Science for a long time
	Learning Science is more fun with the use of eSTAR
	eSTAR increase my motivation to achieve high in Science subject
	eSTAR encouraged me to pursue higher education and careers related to science in the future

The main purpose for this evaluation is to determine the effectiveness of the eSTAR prototype compared to the conventional textbook. Apart from that, to determine whether eSTAR is able to enhance the knowledge retention of students. The evaluation was conducted at the computer laboratory of a secondary school and a computer/laptop equipped with web camera was required to run the eSTAR prototype. Firstly, the respondents in both groups were given a short brief separately regarding the eSTAR prototype. Then, a pre-test was held which comprised of 20 multiple-choice science questions. Then, they were given sufficient time to explore and learn the content of eSTAR for the experimental group. From the following day, they utilized the prototype in their science subject for one week. Then, they are required to answer the post-test questions and also the learning performance questions (AR motivation questionnaire).

For the learning performance study, the pre-test and the post-test were conducted using the same set of questions. The purpose of the pre-test is to determine the respondent's prior knowledge on selected topics while the purpose of the post-test is to determine the knowledge retention after being exposed to the conventional method and the new method of learning. The performance for each group will then be compared to observe for any significant difference in knowledge retention between the pre-test results and post-test results.

3.4.5 Conclusion

The conclusion phase discusses on how to enhance student's motivation towards science learning through the use of the AR technology with the addition of the MM elements. After collecting the needed data through the evaluation, the next step is to analyze the collected raw data. The data is analyzed using SPSS version 22.0. Several statistical analyses have been applied which include; the descriptive statistics, the Pearson correlation coefficient, the regression analysis and the paired-samples t-test to determine whether the expected goal and the objectives are achieved or not.

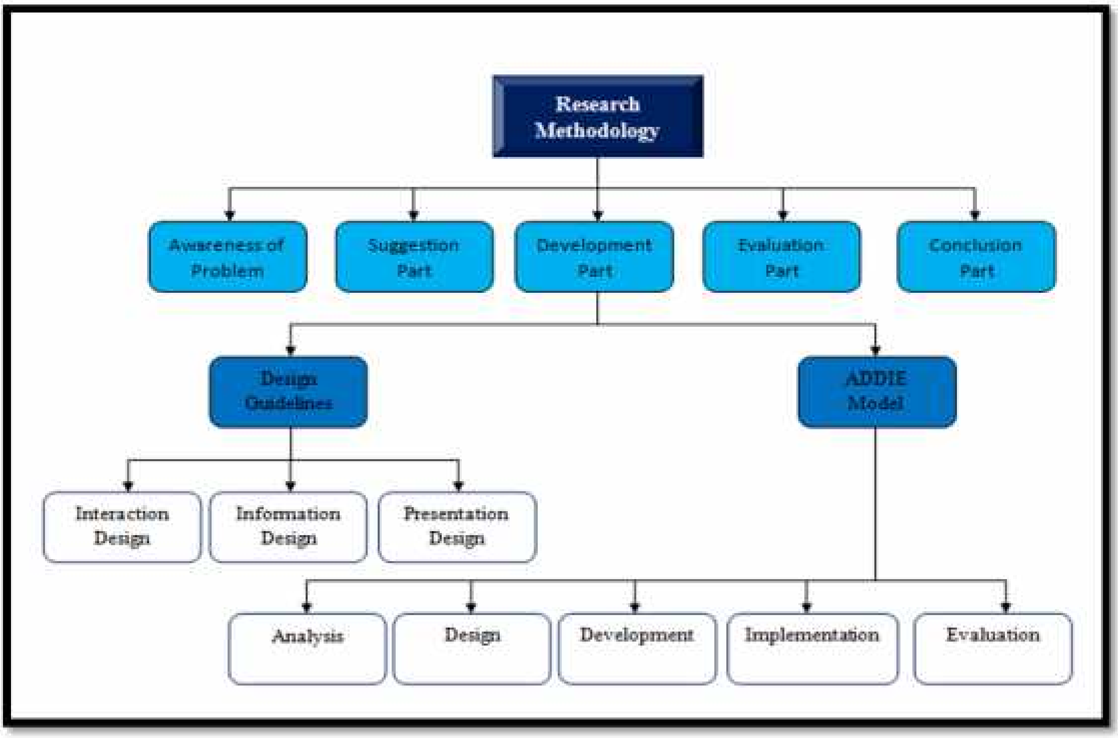


Figure 3.10. Relationship between research methodology, design guideline and ADDIE model

3.5 Summary

This chapter discusses on the overall methods and processes to be implemented in this study. Moreover, the proposed method will contribute to an effective outcome and might have positively changed the students' perceptions and performance in science learning. Moreover, AR with the addition of the MM elements are applied in the development phase and the ADDIE model and three design guidelines are incorporated into this study to create a dynamic and comprehensive learning package for the science learning. Figure 3.10 illustrates the relationship between the research methodology, the design guideline and the ADDIE Model utilized in this study.

CHAPTER FOUR
DESIGN AND DEVELOPMENT OF eSTAR PROTOTYPE

4.1 Overview

This chapter discusses on the eSTAR conceptual model and how this model is being applied in the design and development of the prototype. This chapter describes on the implementation of the components of the conceptual model which include the theories, principles and models. Moreover, it is also discusses on how the components of the conceptual model are utilized in the design and development of the eSTAR prototype. The principles, theories and model are categorized into three major elements namely; design for interaction which explains the interaction between the user and the prototype, design for information which comprises of the contents that are included in the prototype and finally design for presentation which is about the method has been used to present the contents. This chapter also describes the development of the eSTAR prototype.

4.2 The eSTAR Conceptual Model

The conceptual model simplifies and depicts the utilized principle, theories and model (Churchill, 2011) and comprises the identified theories, principles and the hypothesized relationship of the measurements (Sekaran, 2003). It assists the researcher to determine the relationship among those components in enhancing the understanding of the research problem and solution (Zulkifli, Noor, Bakar, Mat, & Ahmad, 2013; Dalle, 2010). The discussion regarding the conceptual model indicates that eSTAR prototype was developed by referring to the conceptual model. First of all, before the conceptual model was developed, the theories, principles and studies related to the research topic was identified and gathered from the literatures.

The conceptual model is a huge asset in a research study because through the use of the model, a researcher, designer and developer are able to visualize a project from the researcher's perspective (Zulkifli et al., 2013).

Before developing the model, a study was conducted to identify the theories, principles and models within the domain area of study which include students' science learning and motivation. A conceptual model assists and guides researchers to evaluate the relationship of the identified measurements in order to understand and find the solutions to the research problems (Benardou, Constantopoulos, Dallas, and Gavrilis, 2010). The eSTAR conceptual model was developed based on several theories, principles and models which are related to motivation. The eSTAR conceptual model comprises of three design components namely; design for interaction, design for information and design for presentation. Each of the design components adapts an element in order to make the model more comprehensive and effective. The design for interaction adapts the User Centered Design; the design for information adapts the Macro Design Strategies and the design for presentation adapts the Micro Design Strategies.

In previous studies, the researchers mentioned that a conceptual model is a representation of a target system designed to be used as a tool for understanding, teaching and learning process (Benardou et al., 2010; Mayer, 1989) and implemented theories and terms in the respective domains. The eSTAR conceptual model as shown in Figure 4.1 is crucial in the design and development of the prototype. The model proposes several prominent guidelines and emphasizes on three prominent elements towards developing the eSTAR prototype. The macro design strategy of this study refers to the eSTAR contents and the micro design strategy refers to the Cognitive Theory of Multimedia Learning (CTML). Further details on how the conceptual model guidelines were used in the eSTAR prototype will be elaborated in following section.

4.2.1 Design for Interaction: UCD

The design for interaction adapts the UCD as a guideline in depicting the activity between the user and the eSTAR prototype. The ADDIE model comprised of UCD presents a systematic prototype development and implementation processes of the eSTAR prototype. Meanwhile, the purpose is to make the eSTAR prototype more comprehensive and able to motivate students to continue in pursuing science-related higher studies and professions. According to Keller (2008), the ARCS model is able to provide a sustainable motivation in a learning process. Moreover, ARCS model is among the most effective and widely accepted motivational model applied in the learning process (Mahadzir & Phung, 2013; Nurtihah et al., 2011; Keller, 2008; Hu, 2008; Huang et al., 2006). Firstly, the Attention factors refer to gaining the student's attention and maintain their engagement in science (Keller, 2008). Secondly, the Relevance factor relates to students' experiences and needs (Keller, 2008). Thirdly, the Confidence factor incorporates students' feelings and expectancy for success (Keller, 2008). Finally, the Satisfaction factor includes strategies that help learners to establish positive feelings towards learning experiences and generate the student's sense of reward and achievement (Keller, 2008). Motivation is an act which encourages someone to do some action (Guay et al., 2010). Motivation is salient for every individual, especially for students. In a learning environment, motivation deals with the problem of setting up conditions so that the learners will perform to the best of their abilities in academics (Guay et al., 2010). Hence, the intrinsic motivation theory was adapted to instrincally motivate students without any extrinsic reward or separable outcome (Ryan & Deci, 2000). Intrinsic motivation provides a long term effect because it is capable to instrincally stimulated a person to involve in learning for a person's own willing and interest without being driven by a reward or any additional incentive (Ryan & Deci, 2000). The first hand experience and the knowledge gained from the learning process cultivate the confidence and motivate the user to perform well in the learning process, especially in science learning (Kerawalla et al., 2006). Moreover, the details regarding the utilization of the conceptual model in developing the eSTAR prototype are shown in Figure 4.1.

Table 4.1 depicts the first attribute of the ARCS model which is the Attention (A). In order to attract user's attention towards science learning through the use of eSTAR, a short Flash montage was designed for the user to start to use the eSTAR prototype for science learning. The intrinsic motivation theory is implemented by merging two applications (Flash and BuildAR) in one learning platform by creating the curios while the 2D animations, a 2D mascot, colourful backgrounds and background music were applied in the montage to grab their attention towards the learning process.

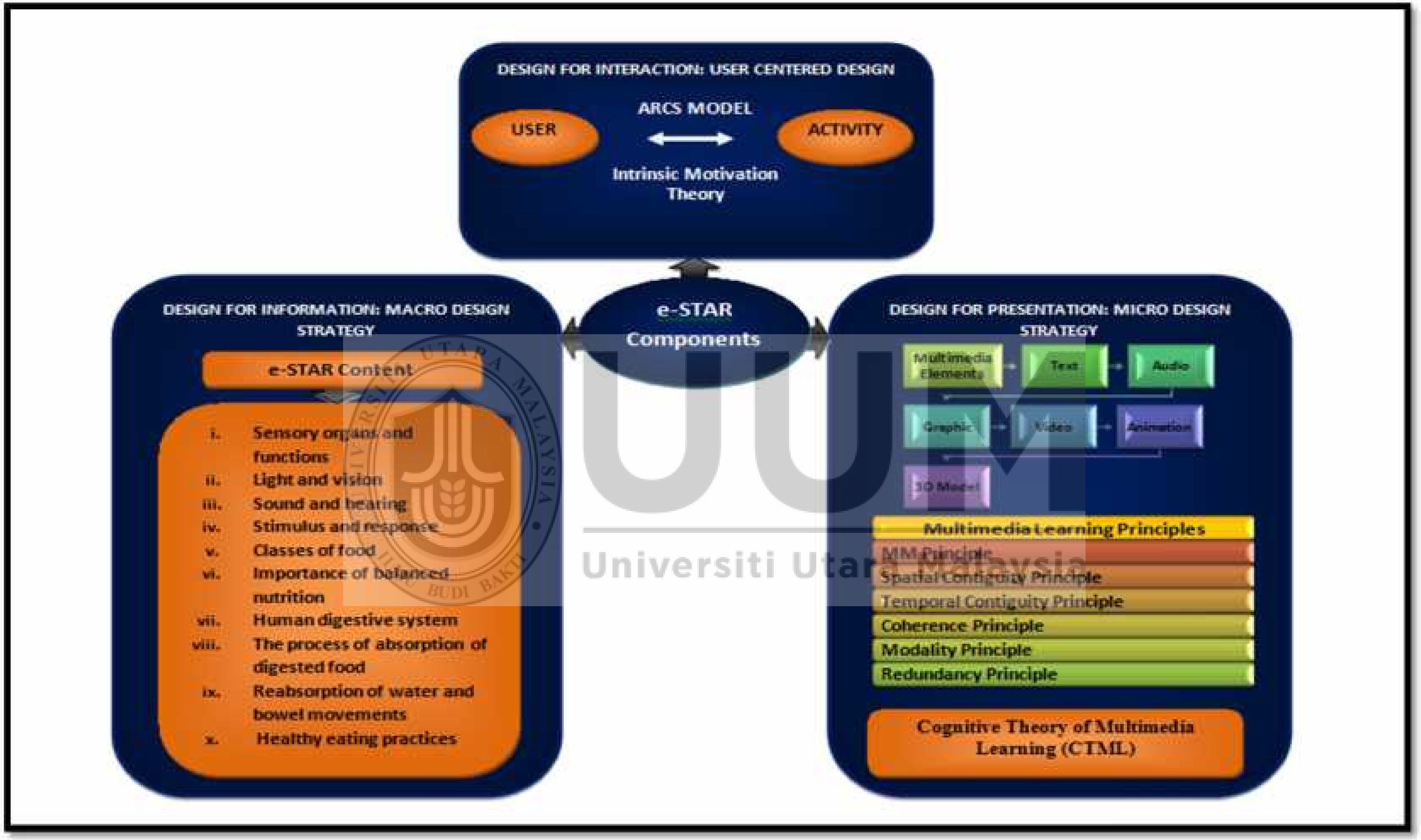


Figure 4.1. The conceptual model of eSTAR prototype design

Table 4.1

The Attribute of the ARCS Model (Attention)

	
Scene 1	***Scene 2***

The second attribute of the ARCS Model is Relevance (R) as shown in Table 4.2. The interactivity between the user and the application is maintained in order to provide an active learning environment. The user is able to choose either to continue with the learning by clicking on the AR Button (see Table 4.2) or view the demonstration video by clicking the next button. Besides that, if the user clicks the AR Button, options to continue the learning process will appear on the screen (see Table 4.2 Scene 5). For this prototype, there are only three options that have been completed namely; Chapter one which is about The World through Our Senses, Chapter two which is about Nutrition and Quiz which enables user to do self-assessment on the respective chapters. Moreover, the demonstration video enables user to conduct self-learning independently and without the need to depend on others. This kind of learning is expected to intrinsically motivate the students and enable them to act independently in any circumstances with confidence, an attribute articulated in the ARCS Model which will be discussed next.

Table 4.2

The Attribute of the ARCS Model (Relevance)

Scene 3 **_Scene 4_**

Scene 5 **_Scene 6_**

Scene 7

As an attribute of the ARCS Model, Confidence (C) motivates the users intrinsically and acts independently without anyone's guidance. The user should feel the confidence and satisfaction after he/she used the new approach of science learning. The eSTAR prototype incorporates the AR technology to encourage learners to be actively involved and fully focused towards the learning process. With the AR technology, markers are used as shown in Figure 4.2 and the markers are sticked onto the pages of the science textbook. In order to activate the virtual contents of the marker, users are required to point the marker to a web camera so that the internally coded virtual contents will be displayed on the screen as shown in Figure 4.3. Once the virtual contents appear, user can start to interact with the content. According to Dunser et al., (2012), by tilting and rotating a book is a kind of interactivity. The eSTAR technology enables the user to view, interact and experience complicated science processes which is impossible to view in real world such as; how the sound vibration stimulate our brain (see Figure 4.4), how the human eye reacts to light (see Figure 4.5) and the internal digestion processes (see Figure 4.6). The first-hand experience and the knowledge gained through the use of the eSTAR prototype help to cultivate the confidence and motivate the users to perform well in science learning.

Figure 4.2. The AR markers for the eSTAR prototype

Figure 4.3. Displaying virtual content through a marker

Figure 4.4. How the sound vibration stimulates our brain

Figure 4.5. How the human eye reacts to light

Figure 4.6. The internal digestion processes

Meanwhile, Satisfaction (S) is the last attribute of the ARCS Model which is very crucial in a learning process. The level of satisfaction that is gained from learning will encourage and motivate the user intrinsically to go through the learning process for several times through the use of the AR technology. The confidence from gaining knowledge and first-hand experience (Kerawalla et al., 2006) provides satisfaction to the user. The user will feel the satisfaction whenever he/she is able to virtually view several human internal processes which are not possible to view in the real world. Additionally, the eSTAR technology provides a short Quiz (see Table 4.3) for the purpose of assessing the knowledge gained by the user after going through the science learning process with the intervention of the AR technology.

Table 4.3

The Attribute of ARCS Model (Satisfaction)

4.2.2 Design for Information: Macro Design Strategies

The design for information is one of the crucial parts in developing a prototype. The type of design information provided to the users must be detailed, complete and valid in order to meet the objectives. Thus, the content itself is a major part of the conceptual model. The eSTAR prototype covers two chapters from the form two science textbook which entirely comprises of ten sub-topics. The science textbook is provided by the Ministry of Education of Malaysian. Besides the textbook, information from other various resources such as supplementary science books and teacher's teaching materials have also been referred to in developing the eSTAR prototype.

The titles of the two chapters of the form two science textbook are; "The World through Our Senses" and "Nutrition". The sub-topics for the first chapter include; i) Sensory organs and functions, ii) Light and vision, iii) Sound and hearing and iv) Stimulus and response. While the sub-topics for the second chapter include; i) Classes of food, ii) Importance of balanced nutrition, iii) Human digestive system,

iv) The process of absorption of digested food, v) Reabsorption of water and bowel movements and vi) Healthy eating practices. Macro design strategies were applied to restructure and organize information in the eSTAR prototype since micro design strategies assist in conveying information accurately and efficiently (Salam, 2010).

4.2.3 Design for Presentation: Micro Design Strategies

A presentation is the medium to convey the eSTAR contents to the users. This sub-section discusses the design method of presenting the contents of the eSTAR prototype. The micro design strategies were adapted in order to present the science contents effectively. Furthermore, the contents of the prototype which consist of multimedia elements that include text, audio, video, and image, animation and 3D models need to be presented to the users by following a set of principles and theory.

The Cognitive Theory of Multimedia Learning (CTML) has been applied in the presentation design. In the CTML, it states that multimedia learning occurs when the learner is able to build the mental representation through the use of text and images. Basically, the human brain does not interpret words, pictures and auditory information in a mutually exclusive fashion, but these elements are selected and organized dynamically to produce a logical model of presentation (Mayer, 2001). The CTML explains the human behavior by understanding their thought processes (Mayer, 2002; Mayer, 2001). According to Mayer & Moreno (1998) and Mayer (2003), the CTML is based on three core assumptions, namely; dual channels (auditory and visual) for processing information and limited capacity of both channels. Last but not least, an active process of filtering, selecting, organizing and integrating information. The cooperation among the MM elements in a learning process might improve the user's long-term memory in storing information and knowledge. Mayer (2001) has identified seven principles of nature and effect of the MM presentation design to the learners. Those are the MM Principle, the Spatial Contiguity Principle, he Temporal Contiguity Principle, the Coherence Principle, the Modality Principle, the Redundancy Principle, and the Individual Differences Principles. The presentation of the virtual contents involving the MM elements is guided by several theories and principles which include the CTML and MM principles.

a. CTML in eSTAR

The CTML has been used to guide in the presentation of the MM elements during the eSTAR prototype development. As stated by Mayer (2005), there are three main assumptions that can be made when it comes to learning with the MM elements. Firstly, the dual-code theory, secondly, the limited channel capacity and thirdly, learning is an active process. The dual-code theory consists of visual and verbal processing and both have limited capacities for processing information. Meanwhile, the MM learning principles were also applied in the eSTAR prototype development. The CTML was incorporated into this study as suggested by Sorden (2012), since the theory provides a powerful impact to the human behaviour especially in motivating the students towards science learning. Further explanations regarding each of the MM learning principles are as follows.

b. MM Learning Principles

Altogether there are seven MM learning principles, namely multimedia principle, spatial contiguity principle, temporal contiguity principle, coherence principle, modality principle, redundancy principle and individual difference principle. In the eSTAR prototype development, only six principles are adapted. The individual difference principle is excluded because the focus group of this study is the Secondary school students and they are not categorized as the high-knowledge, the low-knowledge, the high-spatial or the low-spatial learners.

- **MM Principle**

The MM principle depicts that when an image adds to a word rather the word stand alone, it is able to enhance the learning process. The coalition between words and pictures convey the information more accurately and effectively. The eSTAR prototype provides an effective and proper images and words as shown in the prototype (See Figure 4.7) which discusses the routes of response to stimulus with word and picture of how brain stimulates whenever it receives a response from human's every action.

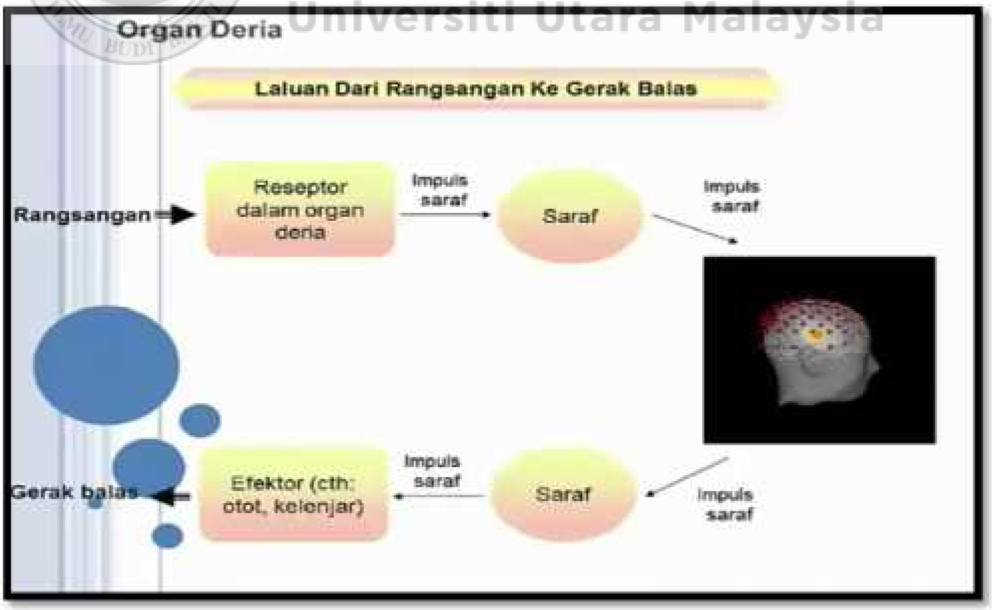


Figure 4.7. Example of dual-code theory in eSTAR prototype (routes of response to stimulus)

- **Spatial Contiguity Principle**

Figure 4.8. Example of spatial contiguity principle in eSTAR prototype (human skin structure)

The graphics (moving or static) in the eSTAR prototype and the words and pictures presented are better understood as compared to when they are far from each other on the page or screen (Mayer, 2001). The graphics were added with images and texts, in order to enhance the understanding. Besides that, the static images were presented along with the explanation of the process and this enable the learner easily understand the actual meaning of the process. The collaboration between texts and pictures provide a useful and effective learning process while the knowledge retention also can be increased.

As shown in Figure 4.8, the human skin structure and it is labelled so that the users could identify and remember the parts of the human skin structure. If only words are provided, the user would not be able to imagine the look of the structure. Meanwhile, if only images are provided, the user could not as well identify the parts of the human skin structure. Thus, the combination of words and picture contributes to effective learning process.

- **Temporal Contiguity Principle**

The temporal contiguity principle claims that by simultaneously presenting words and pictures is a way better than a sequential presentation (Nurtihah et al., 2011). In the eSTAR prototype, words and images are presented together with some movement. It is allowing the user to build the mental connection between verbal (word) and pictorial (image). For instance, the eSTAR prototype (See Figure 4.9) presents regarding to the response of the human eyepiece to the light and how it registers the object or image which seen through the eyes. The animation is presented simultaneously with its words, so that the human information processing system can hold the information.

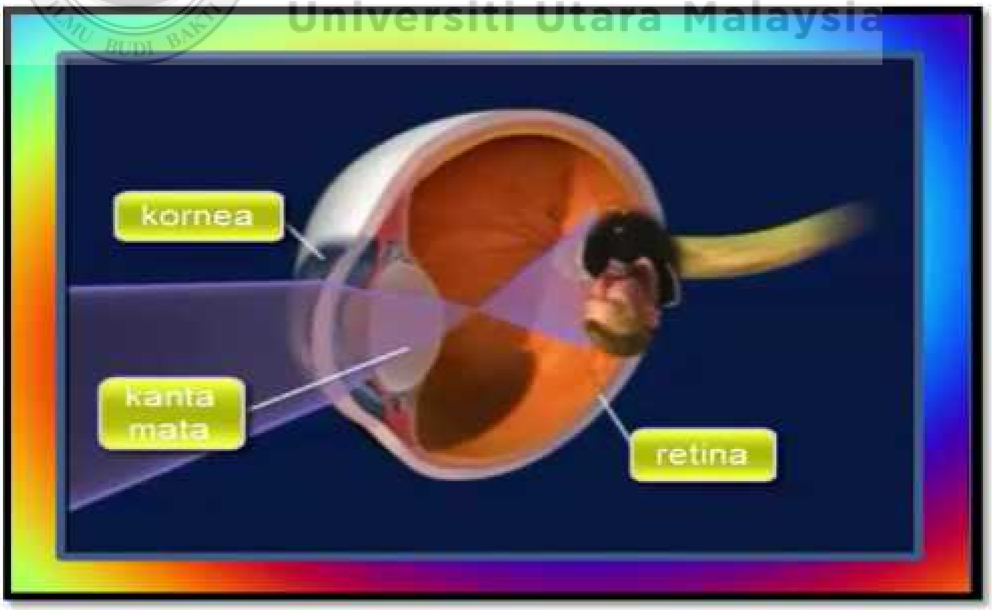


Figure 4.9. Example of temporal contiguity principle in eSTAR prototype (human eye piece)

- **Coherence Principle**

The coherence principle stated that, a learning process could be effective even the image, word and sound are excluded. Therefore, the eSTAR prototype avoided seemingly interesting words, pictures and sounds that were not relevant to the main message. It has narrowed the information presentations as it were kept as concise as possible. The information is presented without any information overflow, and it is presented in an attractive and interactive way. The use of this principle facilitates learners, and it promises a better understanding for the users. As shows in Figure 4.10, only important points in a table format presented without any additional images or descriptions. The mineral is one of the food classes among six other classes. The image depicts several of needed minerals for human beings, source of minerals, and advantage of the mineral and also mineral deficiency diseases.

Figure 4.10. Example of coherence principle in eSTAR prototype (Food Class)

- **Modality Principle**

Animations and narrations are better at learning than from animation and on screen text whereby the users learn better when words in multimedia presentation are presented as spoken text rather than printed text (Gutierrez, 2014; Thiyagu, 2013; Mayer, 2001). The eSTAR prototype implemented this principle for human sensory organs where the contents are presented with animation and narration.

- **Redundancy Principle**

The redundancy principle is about the process of learning from animation, narration, and on-screen text. It avoids the visual channel becoming overloaded when on-screen-text and graphics are both visually presented (as animation and text). The use of narration and words can enhance the users' understanding since both utilize verbal and auditory channels.

4.3 eSTAR Prototype Implementation

After designing the eSTAR, implementation is the next phase in development. As discussed previously, three main processes are adapted for the implementation phase. The three main processes include; Pre-Authoring, Authoring and Post-Authoring.

4.3.1 Pre-Authoring

The first process in the Multimedia Development Process (MDP) is Pre-authoring. In Pre-authoring, it is divided into three steps namely; the Acquire Media, the Digitize Media and the Edit Media. All the steps were followed to implement the eSTAR prototype development.

4.3.1.1 Acquire Media

First and foremost, all the related media in the form of science learning from current textbook, additional revision books, internet sources were collected. Furthermore, eSTAR presents the learning material through the use of AR technology with the addition of MM elements in order to present the content in an effective and useful way. The main reference was derived from the current form two science textbook provided by the MoE. Few other sources were also used to gather additional information which is suggested by the content expert, the teachers who have been teaching the science subject for more than 5 years. The current science textbook provided by the MoE consists of only text and images, while the eSTAR prototype utilizes AR and MM technologies. After gathering all the necessary materials, the next step is to digitize the media.

4.3.1.2 Digitize Media

In this phase, all the gathered materials were digitized. The related audio and video resources were gathered and produced.

4.3.1.3 Edit Media

When all the gathered materials were already in the digital format, the editing processes began. All the materials such text, audio, video, graphics, animation and 3D models were edited using software such as Adobe Photoshop, Adobe Audition, Adobe Premier, Camtasia Studio and Autodesk 3DS Max.

4.3.2 Authoring

Next is Authoring phase in developing the eSTAR prototype. The various media elements were then integrated and synchronized in this phase. BuildAR was used as the AR software for this prototype. Three important steps were involved in this phase and they are explained in the following sections in brief.

4.3.2.1 Import Media

All the related materials to eSTAR were imported into BuildAR. This step is important to ensure that only the imported elements integrated among each other. There are various items that have been imported into the platform software, which include text, audio, video, graphics, and 3D models with animation. Each of the items is internally coded to the respective AR marker so that whenever the marker is being held in front of the web camera, the virtual content will be displayed on the screen.

4.3.2.2 Add Interactivity

For the eSTAR prototype, Build AR is integrated with the main platform that is Adobe Flash. Furthermore, learning through the use of AR is the main agenda of eSTAR. As the main platform, Adobe Flash provides an introduction montage to welcome the user to the learning process and user can choose the chapter to start a learning session. AR is embedded into the platform to allow user to view the virtual contents through the AR markers which are available in the science textbook. Action Script 3.0 was used to integrate between BuildAR and Adobe Flash.

4.3.2.3 Testing and Debugging

Once the prototype is finished, all the AR markers were tested and debugged before moving to the next phase. In order to reduce errors, the testing and debugging processes were deployed many times. Most of the errors are related to typing, video and audio looping, and video and audio format.

4.3.3 Post-Authoring

Post-authoring is the last phase in the implementation of the eSTAR prototype before it could be deployed for user evaluation. In this phase, it involved the packaging of the prototype.

4.3.3.1 Packaging

As the last stage of development, the eSTAR prototype was transferred to the pen drives as a standalone application in the form of an .exe file. Users also have to install the BuildAR viewer in their laptop or computer in order to view the AR application. In this study, the pen drives containing the eSTAR.exe and BuildAR viewer files were distributed among students to be used during the evaluation phase.

4.4 Summary

Details about the eSTAR conceptual model and how the elements in the model are applied in the eSTAR prototype were discussed in this chapter. The three main elements of the eSTAR conceptual model including examples related to the model, theories and principles were also discussed. Apart from that, brief explanations of the eSTAR prototype implementation have also been discussed to give an overview to the reader on how the prototype was implemented.

CHAPTER FIVE
DATA ANALYSIS AND RESULTS

5.1 Overview

Chapter five depicts the evaluation that has been conducted among experts in the field and the secondary school students as a focus group of this study. The evaluation phase includes the perception study, the correlation and the regression analyses and the learning performance study. All the collected data were used to determine; the perception of the students toward the use of the eSTAR prototype, the correlation between the independent variables (Ease of Use, Engaging, Enjoyment and Fun) and the dependent variable (motivation) and finally the students' learning performance due to the intervention of the eSTAR prototype for science learning.

The hypotheses were formulated to justify the effects of the eSTAR prototype among students in science learning. First of all, Cronbach Alpha values were calculated to confirm the reliability and validity of the motivation questionnaire used in the perception study. Furthermore, a heuristic evaluation was conducted to minimize errors in the developed eSTAR prototype. Then, various statistical analyses were applied, namely; descriptive statistics, a paired sample t-test, as well as the correlation and regression analyses. The analyses were conducted using Statistical Package for Social Science (SPSS) version 22.0. Finally, the summary of the findings is presented at the end of the chapter. Figure 5.1 shows the evaluation process for this study.

5.2 Heuristic Evaluation

The first evaluation conducted in this phase was the heuristic evaluation or the expert evaluation. In this study, experts are categorized into two; the content experts are form two secondary school science teachers and the interface expert are lecturers (See Appendix I) who have the experience in teaching and conducting research related to AR and MM and they have more than five years of experience in their respective fields.

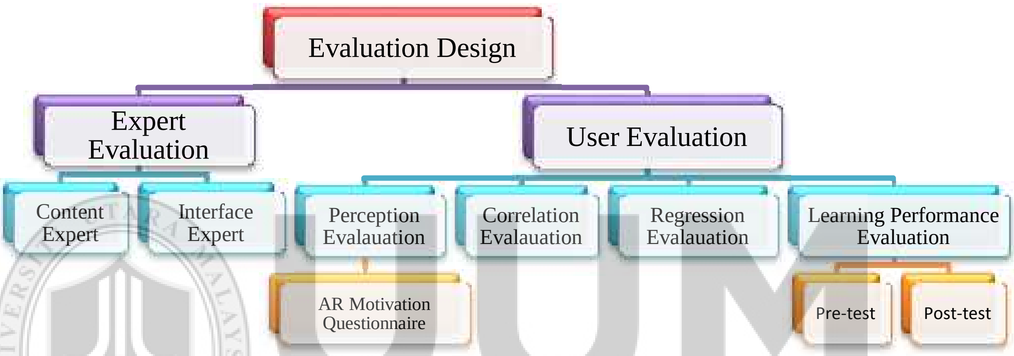


Figure 5.1. Evaluation Design applied to this study

The content experts were responsible to check the validity and the suitability of the scientific contents to be presented to the target users and in this case the form two secondary school students. Meanwhile, the interface experts were responsible to evaluate the functionality and usability of the eSTAR prototype. The feedbacks from the experts were required to correct the errors and mistakes and ensuring that the prototype was functioning as required before being distributed to the users. The purpose of the heuristic evaluation for this study has been discussed in detail in Chapter 2. Table 5.1 shows the problems that have been identified by the experts and suggested solutions to the problems that have been complied during the evaluation phase as adapted from Nielsen (1994).

Table 5.1

Problems and Solutions for Heuristic Evaluation of the eSTAR Prototype

No.	Heuristic	Expert Comments	
		Problem	**Solution**
1.	Visibility of system status	Few AR markers are slowly detected and response.	Rechecked and standardized the size of AR markers. Same type of images is avoided.
2.	Match between system and the real world	Standardize the marker illustration either with real images or cartoon images.	Changed the AR Markers to real type images in order to attract learners.
3.	User control and freedom	-	-
4.	Consistency and standards	Video regarding sense of taste has a spelling error. Suggestion Variety in presenting the content such as video, audio, text, animation and 3D models is good and enough to motivate students.	The word for the video supposed to be tongue instead of the ear. It was corrected.
5.	Error prevention	Technical glitches are existing because it might stop learners from continuing with the apps. Few background sounds are looped.	Avoid technical glitches. It might stop learners from continuing with the apps. Avoid the looping of certain sound in background
6.	Recognition rather than recall	-	-
7.	Flexibility and efficiency of use	**Suggestion** Presentation is good, but provide with a skip button. So, an experienced user can skip the introduction phase and straight to the learning phase.	-
8.	Aesthetic and minimalist design	**Suggestion** Presented content for each chapter is comprehensive and suitable for students	-
9.	Recognize, diagnose, and recover from errors	-	-
10.	Help and documentation	**Suggestion** Clearly state where to stick the marker in the science text book. Provide a step-by-step guide on how to use the AR apps and provide introduction about eSTAR.	-

Table 5.2

Design evaluation of *the eSTAR Prototype*

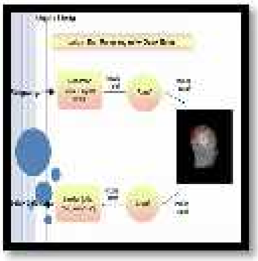
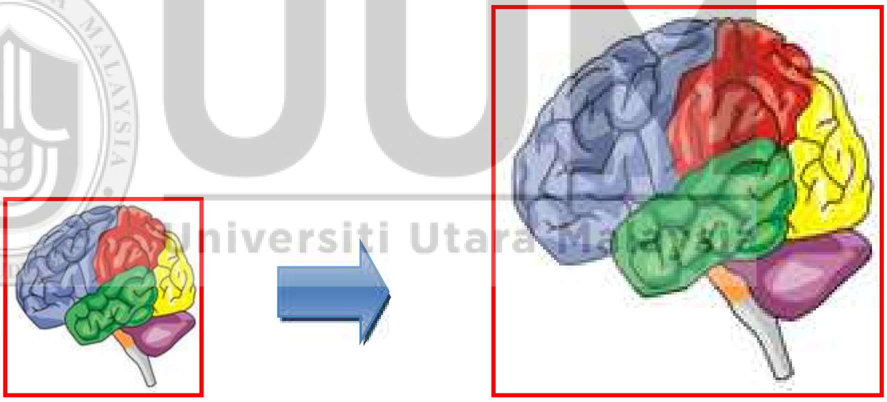
No.	Theory	Diagram/Description	Expert Evaluation	
			Has Been Applied	Has Not Been Applied
1.	Multimedia Principle		✓	
2.	Spatial Contiguity Principle		✓	
3.	Temporal Contiguity Principle		✓	
4.	Coherence Principle		✓	
5.	Modality Principle	✓ Animation and Narration: Has been applied for human sensory organs and provided with on screen- text.	✓	
6.	Redundancy Principle	✓ Animation, Narration and onscreen-text: Has been applied in prototype.	✓	

Table 5.2 depicts the design evaluation of the eSTAR prototype by the interface experts of this study (lecturers) (refer to Appendix L and Appendix M). Six out of the seven principles of CTML were applied in this study and evaluated by the expert. Based on the experts, the principles were well executed in the design and development of the eSTAR prototype.

a. Visibility of system status

The experts have identified the delay in the detection of the AR Marker which influences learner's engagement during the learning process. The changes that have been made are shown in Figure 5.2. After the changes have been made, the marker can be tracked faster.

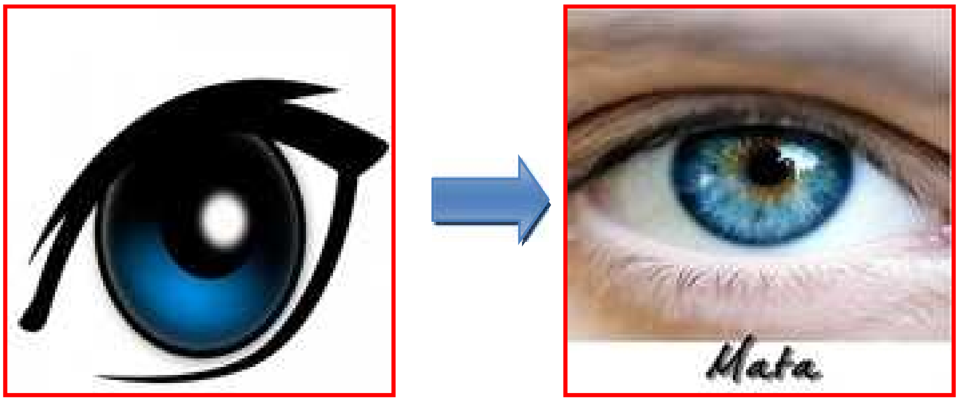


1.0 inches x 1.0 inches   2.0 inches x 2.0 inches

Figure 5.2. Size of AR marker before and after changes

b. Match between system and the real world

The experts have identified that the AR Marker images are mixed between the real and the illustrated images which might confuse the learners. So, they suggested standardizing the marker illustration either with the real images or the cartoon images. The change made to the AR Markers is shown in Figure 5.3.



Cartoon Image Real Image

Figure 5.3. Type of AR marker before and after changes

5.3 Perception Study: User Evaluation

The researcher asked for permission from the state education department to conduct the data collection in the related school (refer to Appendix A). Then, met the headmaster and the school teachers in their office to explain about the research study and the purpose of this study (refer to Appendix B). Then, the researcher discussed with the science teachers as they are the content experts to discuss about the content. Some of the teachers were very supportive while others lack interest in the technology based learning. The content experts involved in this study from the early stage of this research study. Since, this study is related to formal learning, all the content of the eSTAR prototype was checked by the interface expert (teachers) (refer to Appendix L and Appendix M). In order to take part in this evaluation, the students were given a consent form to be filled by their parents. However, since some of the students did not return their parent's consent form, only 140 students were able to take part in the user evaluation. Students were divided into two groups, those who have a laptop or notebook at home and those who do not have a laptop or notebook at home. Altogether there were 70 students who have a laptop or notebook and involved in the user evaluation. The developed eSTAR prototypes were distributed among the users. The AR motivation questionnaire (see Appendix E) was used in the user evaluation. The aim of this evaluation is to determine the users' perception towards the use of the eSTAR prototype which incorporates AR and MM elements such as text, audio, video, graphic and 3D animation as supplementary science learning material.

5.3.1 Sample

Altogether, 70 Form two students chosen as a sample. This satisfies the requirement stated by Coakes & Steed (2003), whereby the minimum number of samples must be at least 30 respondents. The purposive sampling method was utilized in the sample selection. The user evaluation has been conducted in a secondary school in Perak. Table 5.3 shows the Demographic data of the respondents. 32 respondents were male and 38 respondents were female. Since all respondents were form two students, they were 14 years old when they participated in the evaluation. The respondents comprised of 42 (60.0%) Malays, 17 (24.3%) Chinese, 9 (12.9%) Indians, and 2 (2.9%) are from other races. All the respondents were from four different classes. 23 (32.9%) of the respondents were from the 2 Sigma class, 19(27.10 %) were from 2Rka class, 16 (22.9%) were from 2 Lamda class and 12 (17.10%) were from 2 Omega class. All the respondents have a laptop or notebook at home. 40 (57.1%) of the respondents have internet facility at home while 30 (42.9%) did not have the facility. In terms of the frequency of internet usage by respondents, the results indicated that; 20 (35.7%) used daily, 25 (28.6%) used weekly, 16 (22.9%) used monthly, and 9 (12.9%) never used the internet. In terms of knowledge about AR, the results indicated that; 22 (31.4 %) of the respondents have some knowledge about AR and 48 (68.6%) do not have any knowledge about AR.

Table 5.3

Summary of Respondents Demographic Data

Respondent Profile		Frequency	Percentage (%)
Gender			
1.	Male	32	45.70
2.	Female	38	54.30
Age			
1.	14	70	100.00
Race			
1.	Malay	42	60.00
2.	Chinese	17	24.30
3.	Indian	9	12.90
4.	Others	2	2.90
Class			
1.	2 Sigma	23	32.90
2.	2 Rka	19	27.10
3.	2 Lamda	16	22.90
4.	2Omega	12	17.10
Availability of Laptop or Notebook with Webcam			
1.	Yes	70	100.00
Internet Facility At Home			
1.	Yes	40	57.10
2.	No	30	42.90
Frequency of Internet Usage			
1.	Daily	20	35.70
2.	Weekly	25	28.60
3.	Monthly	16	22.90
4.	Never	9	12.90
Knowledge About AR			
1.	Yes	22	31.40
2.	No	48	68.60

5.3.2 Validity and Reliability Test for the AR Motivation Questionnaire

A 5-point Likert scale anchored with 1-strongly disagree, 2-disagree, 3-somewhat agree, 4-agree and 5-strongly agree was used. It consists of five measurements, namely; Ease of use, Engaging, Enjoyment, Fun and Motivation. In order to assess distortion and bias in the questionnaire, validity and reliability tests were conducted. The purpose of the reliability test is to identify the internal consistency and the specified measurement's usability. According to Hair, Black, Babin, Anderson & Tatnam (2006); Nunally (1978) the minimum value of Cronbach Alpha should be 0.7. The Cronbach Alpha value was calculated using SPSS 22.0 software to determine the relationship between multiple measurements of a dimension. Table 5.4 depicts the Cronbach alpha values for all measurements and values of each measurement from reliability evaluation test among 70 respondents.

Table 5.4

Cronbach Alpha Values for All Measurements

Measurement	**Number Of Items**	**Cronbach Alpha** α
Ease Of Use	6	0.780
Engaging	4	0.836
Enjoyment	4	0.802
Fun	4	0.774
Motivation	6	0.865

Since all the Cronbach alpha values ranged between 0.8 to 0.9 and are greater than 0.7, all the measurements and items are highly interrelated and reliable (Nunally, 1978). Motivation (α=0.865) is the dependent variable while the ease of use (α=0.780), engaging (α=0.836), enjoyment (α=0.802) and fun (α=0.774) are the independent variables of this study. The Table 5.5 depicts that all the measurements comprised to evaluate the eSTAR prototype which is based on the eSTAR conceptual model are highly interrelated and reliable.

Table 5.5

Cronbach Alpha for AR Motivation Measurements

No.	Measurement	Scale					
		Excellent	**Good**	**Acceptable**	**Questionable**	**Poor**	**Unacceptable**
		> .9	> .8	> .7	> .6	> .5	< 5
1.	Ease Of use			■			
2.	Engaging		■				
3.	Enjoyment		■				
4.	Fun			■			
5.	Motivation		■				

5.3.3 User Evaluation for each Measurement

User evaluation for each measurement was conducted in order to determine the mean score and the standard deviation. The measurements were the ease of use, engaging, enjoyment, fun and motivation. The following sub-sections discuss each of the measurements in detail.

5.3.3.1 Ease of Use of using the eSTAR Prototype

Figure 5.4 depicts the mean and standard deviation for Ease of Use. The mean is 4.10 and the standard deviation is 0.53. The mean indicates that the respondents agree on the ease of use of the eSTAR prototype as a supplementary learning material for science learning.

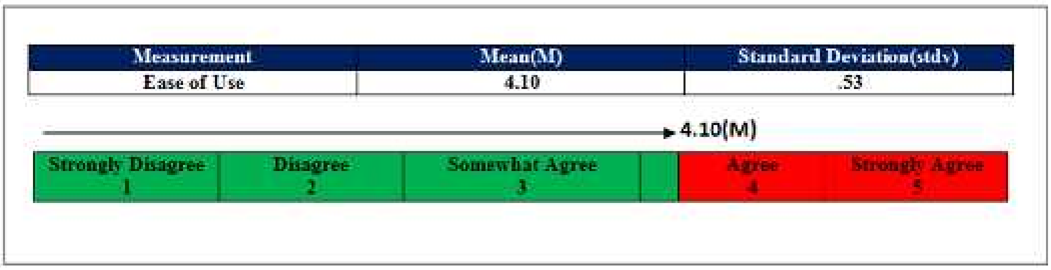


Figure 5.4. Ease of use of the eSTAR prototype

Table 5.6 depicts all the seven items which were included in this measurement. The item having the highest mean (4.14) were the sixth item “Augmented Reality has made the revision process easy”. This shows that the students acknowledged that eSTAR is suitable to be applied for the revision process of Science subject. Meanwhile, the item with the lowest mean (4.01) was the third item “eSTAR is suitable to use as revision tool in Science subject” which indicates that the students agree that eSTAR is easy to use somewhat facing few difficulties to adapt new learning environment.

Table 5.6

Items for Ease of Use

No.	Ease of Use	Mean
1.	eSTAR is easy as an individual	4.03
2.	eSTAR is suitable to apply in Science subject	4.23
3.	eSTAR is suitable to use as revision tool in Science subject	4.01
4.	Augmented Reality is suitable for personal use	4.09
5.	The steps to use the eSTAR is easy to remember	4.11
6.	Augmented Reality has made the revision process easy	4.14

5.3.3.2 Engaging of using the eSTAR Prototype

Figure 5.5 depicts the mean and standard deviation for Engaging. The mean is 4.03 and the standard deviation is 0.68. The mean indicates that the respondents agree that the eSTAR prototype as a supplementary learning material for science learning. This was probably due to other various distractions from the environment that might distract the students leaving them unable to focus and give full attention to learning.

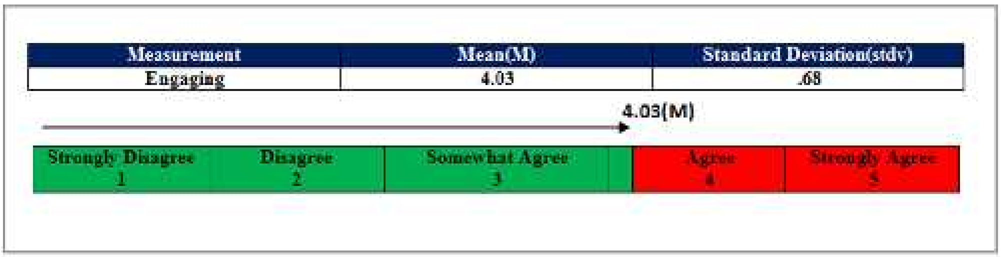


Figure 5.5. Engaging of using the eSTAR prototype

Table 5.7 depicts all the four items which were included in this measurement. The item having the highest mean (4.07) was the fourth item "Augmented Reality increase my involvement in the learning of Science". This shows that the students acknowledged that eSTAR is capable of enhance the engagement towards science learning. Meanwhile, the item with the lowest mean (4.00) was the third item "eSTAR makes me involve in Science studies for a long time" which indicates that the students agree that eSTAR attract them towards Science can subject for a long time.

Table 5.7

Items for Engaging

No.	Engaging	Mean
1.	eSTAR attract my interest in studying Science for a long time	4.03
2.	eSTAR makes me repeatedly revise Science subject	4.03
3.	eSTAR makes me involve in Science studies for a long time	4.00
4.	Augmented Reality increase my involvement in the learning of Science	4.07

5.3.3.3 Enjoyment of using the eSTAR Prototype

Figure 5.6 depicts the mean and standard deviation for Enjoyment. The mean is 4.11 and the standard deviation is 0.57. The mean indicates that the respondents are in the high level of enjoyment in using the eSTAR prototype as a supplementary learning material for science learning.

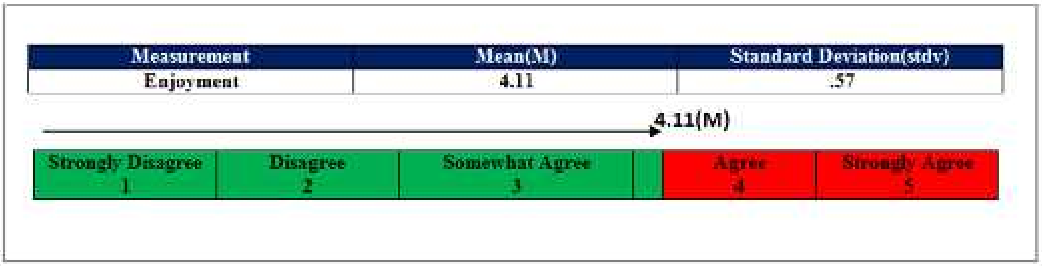


Figure 5.6. Enjoyment scale with eSTAR prototype

Table 5.8 depicts all the four items which were included in this measurement. The item having the highest mean (4.23) was the fourth item "Augmented Reality cultivates the interest in learning science". This indicates that students highly agree that AR that has been used in the eSTAR prototype is able to cultivate their interest in science learning. Meanwhile, the item with the lowest mean (4.00) was the first item "Really like and enjoy the eSTAR prototype in the learning of Science subject" which shows that the students are agree and they do like and enjoy using the eSTAR for science learning.

Table 5.8

Items for Enjoyment

No.	Enjoyment	Mean
1.	Really like and enjoy the eSTAR prototype in the learning of Science subject	4.00
2.	eSTAR made deeply enjoyed the uniqueness Science	4.14
3.	I enjoy learning science by using the eSTAR	4.09
4.	Augmented Reality cultivates the interest in learning science	4.23

5.3.3.4 Fun of using the eSTAR Prototype

Figure 5.7 depicts the mean and standard deviation for Fun. The mean is 4.25 and the standard deviation is 0.53. The mean indicates that the respondents agree in fun of using the eSTAR prototype as a supplementary learning material for science learning.

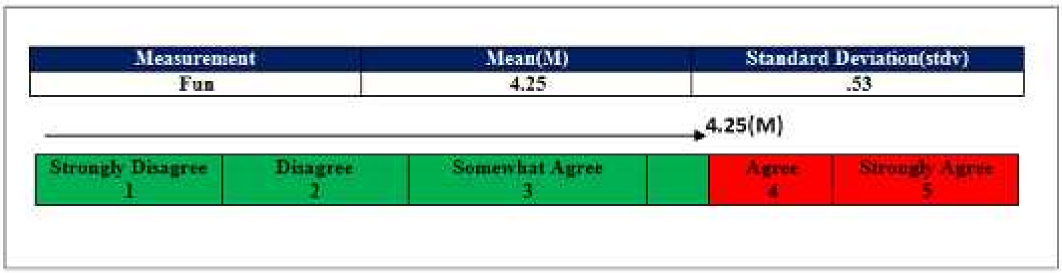


Figure 5.7. Fun scale with eSTAR prototype

Table 5.9 depicts all the four items which were included in this measurement. The item having the highest mean (4.29) was the second item "Contents of the eSTAR prototype adds more fun in learning the science subject". This shows that the students acknowledged and highly agree that the content of the eSTAR prototype is fun to use for science learning. Meanwhile, the item with the lowest mean (4.23) was the third item "I enjoyed using the eSTAR as revision tool in Science" which indicates that the students highly agree that the eSTAR prototype is able to use as supplementary revision tool for science learning.

Table 5.9

Items for Fun

No.	Fun	Mean
1.	eSTAR is very fun to use in the learning of Science subject	4.26
2.	Contents of the eSTAR prototype adds more fun in learning the science subject	4.29
3.	I enjoyed using the eSTAR as revision tool in Science	4.23
4.	eSTAR learning is fun compared with the conventional textbook with normal text	4.24

5.3.3.5 Motivation of using the eSTAR Prototype

Figure 5.8 depicts the mean and standard deviation for Motivation. The mean is 4.15 and the standard deviation is 0.55. The mean indicates that the respondents are highly agree towards motivation in using the eSTAR prototype as a supplementary learning material for science learning which fulfils the main aim of this study.

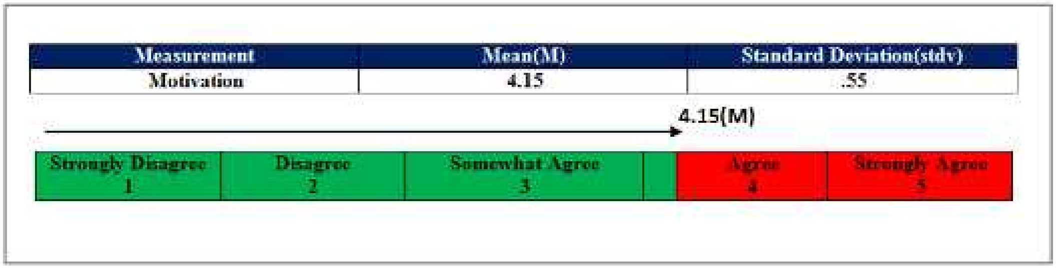


Figure 5.8. Motivation scale with eSTAR prototype

Table 5.10 depicts all the six items which were included in this measurement. The item having the highest mean (4.21) was the sixth item "eSTAR encourages me to pursue higher education and careers related to science in the future". This shows that the students acknowledged that the eSTAR prototype is able to motivate and encourage them to be high achievers towards science. Meanwhile, the item with the lowest mean (4.01) was the third item "I enjoyed the process of learning science for a long time" which indicates that the students only agree that they enjoy science learning for a long time.

Table 5.10

Items for Motivation

No.	Motivation	Mean
1.	eSTAR is really easy to use	4.19
2.	eSTAR increase my involvement in the learning of Science	4.13
3.	I enjoyed the process of learning science for a long time	4.01
4.	Learning Science is more fun with the use of eSTAR	4.17
5.	eSTAR increases my motivation to achieve high in Science subject	4.20
6.	eSTAR encourages me to pursue higher education and careers related to science in the future	4.21

5.4 Correlation Study

The correlation study is a statistical technique to explore the relationships between the independent and dependent variables. In this study the dependent variable is Motivation and the independent variables are the Ease of use, Engaging, Enjoyment and Fun. There are two types of correlation that can be calculated using SPSS namely; bivariate correlation which provides means between two variables and partial correlation which provides the relationship between two variables and at the same time controlling another variable (Pallant, 2013). Pearson correlation is used in this analysis to determine the relationship and strength of the variables (Pallant, 2013). The ideal value for the Pearson correlation coefficient is ranging from -1 to +1 (Pallant, 2013).

Table 5.11 shows the outcome of the correlation coefficient (Davis, 1971). The correlation among the variables is very strong if the value of the correlation coefficient is 0.70 and above. The correlation is strong if the value of the correlation coefficient is between 0.50 and 0.69. The correlation is medium if the value of the correlation coefficient is between 0.30 and 0.49. The correlation is weak if the value of the correlation coefficient is between 0.10 and 0.29. Otherwise, the correlation does not exist among the variables if the value is in between 0.01 and 0.09.

Table 5.11

Correlation Coefficient

Correlation Coefficient	**Strength of Linear Relationship**
0.70 and above	Very Strong
0.50 – 0.69	Strong
0.30 – 0.49	Medium
0.10 – 0.29	Weak
0.01 – 0.09	Not Exist

Table 5.12 presents the Pearson correlation coefficient *(r)* between the dependent variable (Motivation) and the independent variables (Ease of use, Engaging, Enjoyment and Fun). First of all the independent variables; Ease of use, Engaging, Enjoyment and Fun are positively and significantly correlated to the dependent variable which is Motivation. The correlation value for Ease of use is .61, Engaging is .78, Enjoyment is .76 and Fun is .79. All the values indicated that they are strongly correlated to Motivation and the correlation for each variable is significant at the .01 level. Then, Engagement, Enjoyment and Fun are positively and significantly correlated with the Ease of use where the correlation values are .71, .79 and .62 respectively. Followed by Enjoyment and Fun which are positively correlated with Engagement where the correlation values are .83 and .62 respectively and significant at the 0.01 level. Furthermore, Enjoyment also positively correlated to Fun with the correlation value of .66 and significant at the 0.01 level.

Table 5.12

Pearson Correlation Coefficient Analysis

Variables	Motivation	Ease of Use	Engaging	Enjoyment	Fun
Motivation	1				
Ease of Use	.613**	1			
Engaging	.777**	.711**	1		
Enjoyment	.775**	.789**	.829**	1	
Fun	.790**	.617**	.618**	.655**	1

Note: Correlation is significant at the 0.01 level (1-tailed) **

Correlations

		MOT	EOU	ENG	ENJOY	FUN
MOT	Pearson Correlation	1	.613**	.777**	.775**	.790**
	Sig. (1-tailed)		.000	.000	.000	.000
	Sum of Squares and Cross-products	21.152	12.463	20.282	17.073	16.170
	Covariance	.307	.181	.294	.247	.234
	N	70	70	70	70	70
EOU	Pearson Correlation	.613**	1	.711**	.689**	.617**
	Sig. (1-tailed)	.000		.000	.000	.000
	Sum of Squares and Cross-products	12.463	19.572	17.853	14.598	12.141
	Covariance	.181	.284	.259	.212	.176
	N	70	70	70	70	70
ENG	Pearson Correlation	.777**	.711**	1	.829**	.618**
	Sig. (1-tailed)	.000	.000		.000	.000
	Sum of Squares and Cross-products	20.282	17.853	32.240	22.555	15.617
	Covariance	.294	.259	.467	.327	.226
	N	70	70	70	70	70
ENJOY	Pearson Correlation	.775**	.689**	.829**	1	.655**
	Sig. (1-tailed)	.000	.000	.000		.000
	Sum of Squares and Cross-products	17.073	14.598	22.555	22.961	13.971
	Covariance	.247	.212	.327	.333	.202
	N	70	70	70	70	70
FUN	Pearson Correlation	.790**	.617**	.618**	.655**	1
	Sig. (1-tailed)	.000	.000	.000	.000	
	Sum of Squares and Cross-products	16.170	12.141	15.617	13.971	19.812
	Covariance	.234	.176	.226	.202	.287
	N	70	70	70	70	70

**. Correlation is significant at the 0.01 level (1-tailed).

Figure 5.9. Pearson correlation result table

Figure 5.9 above depicts the snapshot from SPSS regarding correlation analysis.

5.5 Regression Analysis

The regression analysis is a statistical process for estimating the relationships among variables and in this study between the independent and the dependent variables as well as to test the hypotheses. Table 5.13 shows the results of the Regression analysis. The R^2 value is 0.775 which depicts the changes in student's motivation regarding to science learning through the intervention of eSTAR. The predictors in the analysis are the independent variables of this study which include the Ease of use, Engaging, Enjoyment and Fun. Moreover, one tailed test was utilized in order to measure the relationship between the variables in order to verify the hypotheses. The acceptable significant t values should be more than 1.645 and p value should be less than 0.05 (Cohen, 2008). Moreover, the purpose of F-ration in the ANOVA table is to determine whether the overall regression model is fit for the data or not. The Figure 5.10 shows that the independent variables statistically significantly predicted the dependent variable, F (4.65) = 55.985 and the regression model is fit for the data.

Table 5.13

Regression Analysis

Variable	**Beta**	**Std. Error**	**t-value**	**Sig (p-value)**
Ease of use	0.10	0.09	1.055	0.30
Engaging	0.29	0.09	3.187	0.00**
Enjoyment	0.22	0.11	2.052	0.04*
Fun	0.49	0.84	5.797	0.00**

**Significance level; $p < 0.01$
* Significance level; $p < 0.05$
Dependent Variable: Motivation
N=70; R Square, 0.775; Adjusted R Square, 0.761; F = (4, 65) 55.985

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics: R Square Change	F Change	df1	df2	Sig. F Change	Durbin-Watson
1	.880[a]	.775	.761	.27057	.775	55.985	4	65	.000	2.425

a. Predictors: (Constant), FUN, EOU, ENG, ENJOY

b. Dependent Variable: MOT

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.394	4	4.098	55.985	.000[b]
	Residual	4.758	65	.073		
	Total	21.152	69			

a. Dependent Variable: MOT

b. Predictors: (Constant), FUN, EOU, ENG, ENJOY

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	.383	.292		1.309	.195					
	EOU	-.098	.093	-.094	-1.055	.296	.613	-.130	-.062	.432	2.316
	ENG	.290	.091	.358	3.187	.002	.777	.368	.187	.274	3.653
	ENJOY	.222	.108	.231	2.052	.044	.775	.247	.121	.272	3.676
	FUN	.491	.085	.475	5.797	.000	.790	.584	.341	.515	1.940

a. Dependent Variable: MOT

Figure 5.10. Regression Table

Figure 5.10 above depicts the snapshot from SPSS regarding regression analysis.

5.6 Learning Performance Study: Pre-test and Post-test

Pre-test and Post-test was implemented in this study to observe the student's learning performance level due to the intervention of the eSTAR prototype for science learning. In order to test the prior knowledge in the respective topics, pre-test was conducted among both control group (exposed to the existing science textbook) and experimental group (exposed to the eSTAR prototype). There were 20 multiples choice questions distributed among students and they were allocated 20 minutes to answer those questions. It is undeniable the fact that student's performance can be observed with one group by observing their prior knowledge and knowledge retention after the intervention, indeed a control group is considered crucial for this study. The control group of students was exposed to the conventional learning method which is through the use of the existing science textbook while the experimental group of students was exposed to the eSTAR prototype. In order to control the students' exposure to other external sources such as TV programme, PowerPoint slides, and videos besides textbook, the evaluation has been conducted with the control group. Furthermore, it assists in evaluating the level of motivation of both groups before and after the intervention. Moreover, by having a control group it can determine the changes in knowledge retention only from using the textbook and not from other external sources.

Meanwhile, interpretation of the pre-test and post-test differences should be done carefully since we cannot be sure whether the differences in pre-test and post-test are solely related to the intervention. Thus, to get the true effect of the intervention of AR in science learning, it is crucial to have both the experimental group and the control group. Furthermore, by having two different groups, the researcher could control the possibility of other factors that are not related to the intervention but responsible for the difference in the pre-test and post-test results. Both groups should have an equal sample size in order to determine the differences.

Nevertheless, the results of the pre-test and the post-test also indicate whether the developed conceptual model is capable to motivate students in science learning. In the pre-test and the post-test, students from both groups are required to answer 20 multiple choice questions (see Appendix D). The results are based on the comparison for both group's pre-test and post-test for students with intervention of AR and students without the intervention of AR in science learning. The same set of questions was used in both the pre-tests and the post-tests. The questions were based on the eSTAR content as mentioned in the conceptual model. There were 70 students in each group with a total of 140 students participated in the performance study as shown in Table 5.14. The snapshot related to pre-test and post-test can be referred in Appendix G.

Table 5.14

The Statistics of Students for Pre-test and Post-test

Groups	**Number of students**
Control	70
Experimental	70
Total number of students	**140**

To assess the learning performance of both groups, paired-sample and independent-sample t-tests were applied. Students in the experimental and control groups differed only in the learning modes used for science learning. The students were classified into two groups based on the availability of Laptop/Notebook. Students in both groups have almost equal academic achievements as testified by the teachers. Tables 5.15 and 5.16 show the learning performance of the control and experimental groups based on paired-sample t-test results. Pre-test scores of both groups represent students' prior knowledge of science which they acquire from other resources such as magazines, TV documentaries, internet and others. The post-test scores of control group represent the learning performance of students through the conventional in the class science learning process. While for the experimental group, the post-test scores represent the learning performance of students through the intervention of the eSTAR prototype for science learning.

Table 5.15

Results of Learning Performance for the Control Group

Evaluation type	Mean	Number of respondents	Std. dev.	Std. Error Mean
Pre-test	8.31	70	2.523	.302
Post-test	12.57	70	2.171	.259

Table 5.16

Results of Learning Performance for the Experimental Group

Evaluation type	Mean	Number of respondents	Std. dev.	Std. Error Mean
Pre-test	9.66	70	3.106	.371
Post-test	14.20	70	3.574	.427

Table 5.17 presents the results of the paired-sample t-test for pre-test and post-test of the control group. The mean score of the control group's pre-test and post-test is increasing from 8.31 to 12.57 and the significance value is 0.00, which is significant at 0.05 and 0.01. This indicates that the students are interested in science subject and also have the motivation to continue to perform better than the previous test.

Table 5.17

Paired-sample t-test of Control Group

Learning Evaluation	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		Mean	Std. Dev.	Std. Error Mean
				Lower	Upper			
Pre-test Post-test	-4.257	1.924	.230	-4.716	-3.798	18.514	69	.000

Table 5.18 presents the result of the paired-sample t-test for pre-test and post-test of the experimental group. The mean score of the experimental group's pre-test and post-test is increasing from 9.66 to 14.20 and the significance value is 0.00, which is significant at 0.05 and 0.01. The paired-sample t-test confirms that there is a significant difference in the learning performance means score for the experimental group. In other words, learning science through the use of the eSTAR prototype generated good learning performance.

Table 5.18

Paired-sample t-test of Experimental Group

Learning Evaluation	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		Mean	Std. Dev.	Std. Error Mean
				Lower	Upper			
Pre-test and Post-test	-4.543	3.479	.416	-5.373	-3.713	10.924	69	.000

Additionally, this study also examines whether learning performance of the experimental group is superior to that of the control group based on independent-sample t-test results. Table 5.19 compares the learning performance of the control groups and the experimental groups based on independent-sample t-test results. Results show that pre-test mean scores for both groups differ significantly. Next, this study assesses whether the difference in post-test scores for both groups is significant based on independent-sample t-test results. Results reveal that post-test scores for both groups differ significantly in motivating students to perform well after both methods of intervention in science learning.

Table 5.19

Comparing results of Learning Performance between Control and Experimental Groups

Group	**Pre-test mean (std.)**	**t**	**Sig. (two-tailed test)**	**Post-test mean (std.)**	**t**	**Sig. (two-tailed test)**
Control	8.31	27.576	0.00	12.57	48.453	0.00
Experimental	9.66	26.011	0.00	14.20	33.245	0.00

5.7 Testing of Hypotheses

This section presents the findings of the analyses of null hypotheses as stated in Chapter 1 and they are as follows;

Hypothesis $_{01}$*:* There is no significant relationship between Ease of use and motivation in the eSTAR prototype.

Hypothesis $_{02}$*:* There is no significant relationship between Engaging and motivation in the eSTAR prototype.

Hypothesis $_{03}$*:* There is no significant relationship between Enjoyment and motivation in the eSTAR prototype.

Hypothesis $_{04}$*:* There is no significant relationship between Fun and motivation in the eSTAR prototype.

Hypothesis $_{05}$: There is no significant difference in the respondents' learning performance between the pre-test and post-test means scores of the control group.

Hypothesis $_{06}$: There is no significance difference in the respondents' learning performance between the pre-test and post-test means scores of the experimental group.

5.7.1 Testing Hypothesis $_{01}$

Hypothesis $_{01}$: There is no significant relationship between Ease of use and motivation in the eSTAR prototype.

Based on Table 5.13, since the significance value is 0.3 which is greater than 0.05, the null hypothesis is accepted. Therefore, there is no significant relationship between Ease of use and motivation in the eSTAR prototype.

5.7.2 Testing Hypothesis $_{02}$

Hypothesis $_{02}$: There is no significant relationship between Engaging and motivation in the eSTAR prototype.

Based on Table 5.13, since the significance value is 0.00, the null hypothesis is rejected. Therefore, there is significant relationship between Engaging and motivation in the eSTAR prototype.

5.7.3 Testing Hypothesis $_{03}$

Hypothesis $_{03}$: There is no significant relationship between Enjoyment and motivation in the eSTAR prototype.

Based on Table 5.13, since the significance value is 0.04, the null hypothesis is rejected. Therefore, there is significant relationship between Enjoyment and motivation in the eSTAR prototype.

5.7.4 Testing Hypothesis $_{04}$

Hypothesis $_{04}$: There is no significant relationship between Fun and motivation in the eSTAR prototype.

Based on Table 5.13, since the significance value is 0.00, the null hypothesis is rejected. Therefore, there is significant relationship between Fun and motivation in the eSTAR prototype.

5.7.5 Testing Hypothesis $_{05}$

Hypothesis $_{05}$: There is no significant difference in the respondents' learning performance between the pre-test and post-test mean scores of the control group.

Table 5.16 presents the result of the paired-sample t-test for pre-test and post-test of the control group in which the significance value is 0.00. Thus, null hypothesis is rejected. Therefore, there is significant difference in the respondents' learning performance between the pre-test and post-test mean scores of the control group.

5.7.6 Testing Hypothesis $_{06}$

Hypothesis $_{06}$: There is no significance difference in the respondents' learning performance between the pre-test and post-test mean scores of the experimental group.

Table 5.17 presents the result of the paired-sample t-test for pre-test and post-test of the experimental group in which the significance value is 0.000. Thus, null hypothesis is rejected. Therefore, there is significance difference in the respondents' learning performance between the pre-test and post-test mean scores of the experimental group.

Table 5.20 presents the summary of the hypotheses testing results.

Table 5.20

Summary of the Hypotheses Testing Results

Hypotheses	**Variable**	**Results**
H_{01}	There is no significant relationship between Ease of use and motivation in the eSTAR prototype.	Null hypothesis is supported
H_{02}	There is no significant relationship between Ease of use and motivation in the eSTAR prototype.	Null hypothesis is not supported
H_{03}	There is no significant relationship between Enjoyment and motivation in the eSTAR prototype.	Null hypothesis is not supported
H_{04}	There is no significant relationship between Fun and motivation in the eSTAR prototype.	Null hypothesis is not supported
H_{05}	There is significant difference in the respondents' learning performance between the pre-test and post-test means score of the control group.	Null hypothesis is not supported
H_{06}	There is a significant difference in the respondents' learning performance between the pre-test and post-test means score of the experimental group.	Null hypothesis is not supported

5.8 Comparison between Previous Findings and Findings of This Study

As mentioned earlier, four measurements (ease of use, engaging, enjoyment and fun) were used to measure motivation in science learning among students. Based on the results of this study, the measurements engaging, enjoyment and fun are significantly related to motivation. The measurements are proposed and evaluated by experts in the field. Based on previous evaluation results, AR with multimedia based learning was able to provide Engaging (Pribeanu, 2014; Rasalingam et al., 2014; Ramli et al., 2012; Abhishek et al., 2013; Dunser et al., 2012; Abas & Zaman, 2011; Vate-U-Lan, 2011; Yuen et al., 2011; Yeom, 2011; Yusoff et al., 2010; Zainuddin et al, 2010; Wrzesien & Raya, 2010; Martín-Gutiérrez et al., 2010; Dede, 2009; Dunser & Hornecker, 2007; Mckenzie & Darnell, 2004 & Billinghurst et al., 2001), Enjoyment (Pribeanu, 2014; Cai et al., 2014; Ibáñez, Di Serio et al., 2014; Ramli et al., 2012; Davidsson et al., 2012; Abas & Zaman, 2011; Simeone et al., 2011; Balog & Pribeanu, 2010; Wrzesien & Raya, 2010; Billinghurst et al., 2001 and Fun (Rasalingam et al., 2014; Ramli et al., 2013; Yusoff et al., 2010 and Mckenzie & Darnell, 2004) and enhance the motivation. However, in this study, Ease of use is not significantly related to motivation. This is in line with Pribeanu (2012) statement where users may not find AR as easy to use since new users to AR need to get used to the new learning environment and be comfortable with it.

5.9 Summary

The purpose for this evaluation is to determine whether the developed eSTAR prototype based on the constructed eSTAR conceptual model is capable to motivate the user's to perform well in science or not. In order to prove it statistically, several statistical analyses such perception study, pearson correlation analysis; regression analysis and learning performance study were conducted. The results obtained from the analyses, statistically confirmed that the eSTAR prototype is able to motivate students and enhance their knowledge retention and perform well in science. Eventhough, the conventional method also significantly enhances the knowledge retention; eSTAR proved that it could be utilized as supplementary learning tool to enhance user's motivation level. Through the findings the main objective of this study has been successfully achieved.

CHAPTER SIX
CONCLUSION OF THE RESEARCH

6.1 Overview of the Chapter

This is the final chapter to conclude the overall findings from this study. It describes the accomplished objectives, the contribution to the body of knowledge, acknowledged limitations and recommendations for the related study in the future. The following subsection discusses in detail about the whole study.

6.2 Research Discussion

The goal of this study is to design and construct a conceptual model of Augmented Reality Enhanced Textbook (eSTAR) in motivating the science learning. Then, a prototype of an enhanced science textbook through the use of AR (eSTAR) was developed followed by the process of conducting perception, regression, pearson correlation and learning performance study to evaluate student's motivation as stated in Chapter One (Introduction). The obtained results from the evaluation can be viewed in Chapter Five (Data Analysis & Results). This research study was conducted in order to achieve five objectives as stated below.

i. To construct a conceptual model in designing the eSTAR.

ii. To design and develop the eSTAR based on the conceptual model.

iii. To measure and determine the relationship between students' motivation towards the use of Enhanced Science Textbook using AR.

iv. To measure students learning performance with the intervention of Enhanced Science Textbook using AR in Science learning.

There are few keywords in the research objective in reference to this study. These include developing, construct and measure. So, the research studies were conducted within these dimensions. In order to accomplish all the objectives, five research questions were developed.

i. How to conceptualize a model of an Enhanced Science Textbook using AR in motivating students to learn science?
ii. How to develop the AR Enhanced Science Textbook in motivating students to learn science?
iii. What is the relationship between the students' motivation towards Enhanced Science Textbook using AR?
iv. What are the students learning performance towards Enhanced Science Textbook using AR?

As discussed in chapter one, this study proposed a conceptual model of Augmented Reality Enhanced Textbook in motivating science learning by incorporating a number of motivation theories, components and models accompanied by the development of a prototype of an enhanced science textbook through the use of AR (eSTAR). This conceptual model can be utilized as a guideline in designing and developing an eSTAR prototype in the future by other researchers.

All the components mentioned earlier were implemented in developing the prototype. Furthermore, the perception study was taken into consideration to determine the motivation of users towards the use of the eSTAR prototype in science learning. Since, the perception of human has the tendency to change thus, the learning performance study was conducted to determine the performance of the students before and after being exposed to the conventional science learning and the eSTAR prototype learning through pre-test and post-test. The results of the evaluations represent the usability and effectiveness of the proposed conceptual model. The following sub-sections discuss more about this research study.

6.2.1 Designing and Constructing an eSTAR Conceptual Model

From the previous literatures, it is clearly stated that motivation is fundamental and very crucial for education especially in science learning (Yen et al., 2013; Sevinc et al., 2011; Yen, Tuan, & Liao, 2011). Thus, the eSTAR conceptual model was designed based on the previous literatures. Furthermore, the purpose of designing and constructing a conceptual model is to guide the further paths in a research study. A conceptual model enables the researcher to put more emphasis on the proposed problem and enable to develop a prototype within the scope. In this study, it was based on the lack of motivation in learning and pursuing science-related domains and the model should consider the motivation factors in order to motivate the users. So, the users should be motivated in science subjects and the focused group in this study is the secondary school students, particularly those in form two. Hence, the contents and elements should be in parallel to their level of knowledge. Furthermore, science-related subjects are important not only to achieving high grade in school but the knowledge will assist an individual in critical thinking and being able to make decisions in life. So, they should be motivated intrinsically which give long-term changes to the users. Thus, the motivation theory has been incorporated in designing and constructing the eSTAR conceptual model.

All the elements, theories and models are categorized into three main parts. These encompass of design for interaction, design for information and design for presentation. Moreover, implementing those designs is considered an ideal decision in order to produce an effective and comprehensive model and prototype. Additionally, more information regarding the eSTAR conceptual model and the illustration of the model can be viewed in Chapter Four (Design and Development of eSTAR prototype). This is then followed by a combination of related theories, model and principles that has been included into the designs. The ARCS Model and Intrinsic Motivation Theory were incorporated in the design for interaction (UCD), the eSTAR contents were implemented in the design for information (macro design strategies) and finally the MM learning principles and Cognitive Theory of MM Learning(CTML) were implemented in the design for presentation (micro design strategies). All of these implementations in the eSTAR conceptual model aimed to motivate the form two students to perform well in the science-related subjects and to pursue their future careers in science related professions.

6.2.2 Developing the eSTAR Prototype

The second objective is to develop the eSTAR prototype and used the constructed conceptual model as a guideline in the development. The designs were utilized as shown in Figure 6.1. These designs were adapted from the previous literatures in order to enhance the motivation level of students towards science subject and increase their performance consistently. Several elements were considered as it is prominent and related in enhancing the student's motivation level such as the interaction between the user and the eSTAR prototype, including the selected science learning content and also most importantly the presentation method as it is very crucial in delivering information to the user.

Figure 6.1. The eSTAR conceptual model designs

The design for interaction was implemented in the User Centered Design (UCD) (Chan & Jaafar, 2009). The model assists the developer and researcher to develop the eSTAR prototype in the future. According to Constantine (2006) cited by Nurtihah et al., 2011, an interaction design is able to influence the usability of a prototype. Thus, the interaction design was incorporated in the eSTAR prototype.

The second phase in the model is the design for information. The design for information is very prominent as it is related to the formal learning contents and also the involved students. The included information must be academic and in coherence to form two student's level. Thus, macro design strategies were implemented in the design for information from the instructional design as shown in Figure 6.1. Furthermore, instructional design assists in selecting accurate and reliable information and how to classify and organize the selected contents (Reigeluth et al., 1982). The main content for the eSTAR was adapted from the science textbook which is currently being referred to by the students. In order to attract students' attention towards this method of learning, the selected contents are conveyed in the form of images, audio, video, and 3D models. The information was maintained but the presentation method was changed. For instance, a text base content conveyed in audio and video to attract the student's attention.

Last but not the least, the design for the presentation has been taken into consideration in this study. The presentation also has equal importance in conveying the information like the information design. The method of presenting information plays a major role because it provides the first impression to the students about the prototype. Then only they are allowed to explore the content. In realizing the importance, this study included micro design strategies into the presentation design. The micro design strategy will guide the design for presentation. Moreover, the micro design strategies included several principles in order to guide the presentation design. As proposed in the eSTAR conceptual model, the MM learning principles and the Cognitive Theory of MM Learning (CTML) are incorporated in this study.

6.2.3 The eSTAR Prototype Evaluation

This evaluation was conducted in order to achieve the last objective of this research study. There are three analyses which were conducted comprising of perception study, Pearson correlation, and regression and learning performance study. The perception study evaluates the students' perceptions towards the constructed AR enhanced textbook. The Pearson correlation study observes the relationship among the independent variables and the dependent variable while the regression analysis determines whether to accept or reject the null hypothesis. Moreover, since the perception evaluation has a potential to change in the future, hence, the performance study was conducted to observe the students' performance level before and after the intervention by implementing the pre-test and post-test.

In order to control other external intervention such as internet source and videos, this study has been designed to have a control group. Thus, an experimental design with a control group was formed. The experimental design consists of a control group and an experimental group. The students in the experimental group were allowed to access the learning content from the AR enhanced textbook (eSTAR), while the students in the control group had the conventional method of learning. Both perception study and performance study were used to analyze the collected data by implementing inferential and descriptive statistical procedures. In addition, 20 multiple choice questions prepared by the content experts (teachers) were utilized for both pre-test and post-test (see Appendix D). The respondents from both groups went through the pre-test and post-test. Furthermore, the Paired Samples t-Tests depicted the significant level for all the collected data and the correlation study reveals the relationship of the variables.

Four null hypotheses were formulated for the descriptive statistical procedures in the perception study and additional two null hypotheses were formulated for the learning performance study as shown in Table 6.1. The findings from the evaluations indicated that five of the null hypotheses were rejected. Meanwhile, the findings from the pearson correlation analysis suggest that the variables are positively correlated to motivation with significance level of ($p < 0.01$ and $p < 0.05$). While for the regression analysis, the variables are positively correlated to motivation with significance level of ($p < 0.01$ and $p < 0.05$) as shown in Table 6.2. The Ease of use measurement is positively correlated to motivation but it is not significant and the null hypothesis is accepted. This result is in line with the statement of Pribeanu

(2012). According to Pribeanu (2012), AR concept in standalone application may cause to few usability problems such as how to learn through it, ease of use and exhaustion.

Besides that, the results illustrated that there is an increase in the correct answers for the questions and have significant difference after the intervention of the AR enhanced textbook while the performance of the other group is deteriorating and with no significance. This showed that the proposed model has the ability to uplift the respondent's performance. Furthermore, it is proven that the flow of organizing the elements in the application and the presentation method is able to attract the respondents towards the learning process.

For the descriptive statistics, overall the items of motivation questionnaire indicated that the mean scores range between 4.00 and 4.30. The mean score revealed that the respondents accepted the proposed technology in their formal learning as supplementary learning material. Moreover, significant differences exist in the performance among the group with the intervention of the AR enhanced textbook and the conventional textbook. This revealed that even the mean score is below the acceptable level but still have the potential to motivate the respondents.

Table 6.1

The Hypotheses of Perception and Performance Evaluations

Num.	Hypotheses	Findings
Perception Study		
1.	There is no significant relationship between Ease of use and motivation in the eSTAR prototype.	Null hypothesis is supported
2.	There is no significant relationship between Ease of use and motivation in the eSTAR prototype.	Null hypothesis is not supported
3.	There is no significant relationship between Enjoyment and motivation in the eSTAR prototype.	Null hypothesis is not supported
4.	There is no significant relationship between Fun and motivation in the eSTAR prototype.	Null hypothesis is not supported
Learning Performance Study		
5.	Experimental Group There is no significant difference in the mean scores of respondents' motivation level between pre test and post test.	Null hypothesis is not supported
6.	Control Group There is no significant difference in the mean scores of respondents' motivation level between pre test and post test.	Null hypothesis is not supported

Table 6.2.

The Pearson Correlation Coefficient Analysis

Num.	Relationship between Variables	Results
1.	Relationship between ease of use and motivation.	Variables are positively correlated
2.	Relationship between engaging and motivation.	Variables are positively correlated
3.	Relationship between enjoyment and motivation.	Variables are positively correlated
4.	Relationship between fun and motivation.	Variables are positively correlated

6.3 Research Contributions

A few contributions to the body of knowledge from this research study have been identified. The following sections elaborate the contributions.

i. An eSTAR Conceptual Model

An eSTAR conceptual model is the most prominent contribution to a research study. The model clarifies all the utilized theories, elements and principles in the eSTAR prototype. Moreover, the entire contents of the conceptual model play a major role to strengthen the design guidelines. This is an effort to attract the attention of students to learn and consistently performing well in academics especially in science subject through the use of the AR technology with the addition of diversified MM elements. As discussed earlier, there were three important designs included in designing and constructing the conceptual model. The primary purpose for the implementation is to boost up students' learning motivation in science through the use of the eSTAR prototype. Since the achievement level in science subject facing a deteriorating trend a proper guideline is very crucial to be constructed.

ii. An Augmented Reality enhanced textbook (eSTAR)

Besides that, developing an AR enhanced textbook (eSTAR) prototype is the second contribution to the body of knowledge. Appendix H can be referred for eSTAR screenshots. This prototype was developed by referring to the eSTAR conceptual model. This is an effort to be used as a supplementary learning material by the students for their academic purpose especially for form two science subject. Based on the findings from the evaluation, this prototype has the ability to boost up the students' performance level and motivation to perform well in science subject. Furthermore, it has been proven that the proposed conceptual model in some way succeeded to lure the students and enhance the motivational level of learning and performing well in the science subject.

iii. Result from Learning Performance Study

The results obtained from the perceived science learning motivation evaluation are the third contribution to the body of knowledge. The target of this evaluation is to scrutinize the knowledge learnt after the intervention of the AR enhanced textbook in learning science subject. Overall, the learning performance of students in both groups had a significant difference in mean scores between the pre-test and post-test. The difference in mean scores for the experimental group is 4.54 while for the control group is 4.26. These indicate that the experimental group has a higher difference in mean scores. The analytical results indicate that both methods of learning are able to increase the learning performance of the students. However, through the use of the eSTAR, the students from the experimental group have a better score in the post-test and eventually resulted in a better learning performance compared to those who were exposed to the conventional science learning.

6.4 Research Limitations

The following section describes the problems and limitations that have to be dealt with during the research process.

i. Identifying a suitable AR platform for the markerless concept was one of the limitations. Since, this is the markerless concept instead of markers, there are certain things to be taken into consideration. These include that each marker images should be different to make it easier and speedier for the tracking process. Then, size and illustration of the marker should be considered because it affects the duration of tracking for each marker. There are plenty of AR platforms available but only very few that provide the markerless concept as well as producing standalone .exe format.

ii. High capacity computer hardware is needed for the development of the eSTAR prototype. Due to the limitation in the Random Access Memory (RAM), the computer will be automatically shut down and the application took a longer time to turn on and render the application.

iii. After the prototype evaluation, the researcher asked for the permission from the headmasters to conduct the data collection and the teachers for the evaluation phase. There are some schools that refused to be part of the evaluation. It was challenging in convincing the teachers to proceed with this evaluation because they were hesitant to try something new in exchange to the conventional learning method. Since the evaluation process includes 140 students who were divided into the experimental group and the control group. Overall this process took 4 weeks to complete the evaluation process. This is due to some procedure and rules in school premises that have to be adhered to by the researcher such as have to wait till the teacher covered all the assessment for the year in order to avoid any interruptions in their teaching and learning process.

6.5 Future Recommendations

In this research, some interesting issues were identified and the recommendations are discussed as follows. The eSTAR prototype is limited to only two topics out of ten topics altogether. In the future, the contents of the eSTAR prototype can be extended so that they cover the whole science textbook. This study is limited to only form two students in a school. It can be extended to several secondary schools in determining the students' motivation pertaining to the use of the eSTAR prototype. Furthermore, the time allocation for the performance study should be extended to three to four weeks in order to give the students more time to adapt to the new learning material and environment. By then, in the future, students will get used to the AR learning process. Other than that, they developed eSTAR conceptual model can provide guidelines for science teachers in designing and developing their own AR based science teaching materials. Last but not least, the eSTAR prototype can be developed on a different platform such as mobile application for the students since the younger generations are born with the technology and they grow up with gadgets.

6.6 Research Summary

The ultimate goal of this research study is to achieve all the proposed objectives as discussed in Chapter One. According to the research objective, this research study have successfully constructed the eSTAR conceptual model and developed the AR enhanced textbook (eSTAR). Based on the findings, there is a significant difference in student's performance and positively correlated between variables. Since Malaysia is among the developing country, youngsters with a strong science background are highly needed for the country's development. Furthermore, the constructed conceptual model can be used as guideline to develop the AR enhanced textbook. Based on the findings, the eSTAR prototype has the capability to change the student's perception towards the science subject and also improve their learning performance. In short, the implementation of eSTAR into science learning is hoped to motivate students to perform well consistently and motivate them to pursue their higher education and career in science related fields. However it is not aimed to replace the current education system. It is merely a supplementary learning material that can be used to encourage and motivate students so that they are aware of the importance to excel in the fields of science not just for their own sake but also for the sake of the nation.

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Appendix A

Permission from Perak State Education Department

AWANG HAD SALLEH
GRADUATE SCHOOL OF ARTS AND SCIENCES
UUM College of Arts and Sciences
Universiti Utara Malaysia
06010 UUM SINTOK
KEDAH DARUL AMAN
MALAYSIA

UUM
Universiti Utara Malaysia

Tel: 604-928 5219/5205/5201
Faks (fax): 604-928 5297/5298
Laman Web (Web): http://ahsgs.uum.edu.my

KEDAH AMAN MAKMUR • BERSAMA MEMACU TRANSFORMASI

UUM/CAS/ AHSGS/813615

5 June 2014

TO WHOM IT MAY CONCERN

Dear Sir/Madam

DATA COLLECTION FOR PROJECT PAPER/ THESIS

This is to certify that Ms. **Valarmathie a/p Gopalan (matric number: 813615)** is a full time graduate student in Master of Science (Multimedia Studies) at UUM College of Arts and Sciences.

She needs to do her field study and data collection for her project paper/thesis in order to fulfill the partial requirements of her graduate studies.

We sincerely hope that your organization will be able to assist her in the data collection and the distribution of the questionnaires for her research.

Thank you.

"SCHOLARSHIP, VIRTUE, and SERVICE"

Yours faithfully

WAN NORHASHIMA BINTI WAN SHE...
Assistant Registrar
for Dean
Awang Had Salleh Graduate School of Arts and Sciences
UUM College of Arts and Sciences

.../11/2014

Universiti Pengurusan Terkemuka
The Eminent Management University

Appendix B

Permission from School

AWANG HAD SALLEH
GRADUATE SCHOOL OF ARTS AND SCIENCES
UUM College of Arts and Sciences
Universiti Utara Malaysia
06010 UUM SINTOK
KEDAH DARUL AMAN
MALAYSIA

UUM
Universiti Utara Malaysia

KEDAH AMAN MAKMUR • BERSAMA MEMACU TRANSFORMASI

UUM/CAS/ AHSGS/813615

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TO WHOM IT MAY CONCERN

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Thank you.

"SCHOLARSHIP, VIRTUE, and SERVICE"

Yours faithfully

WAN NORHASHIMA BINTI WAN ...
Assistant Registrar
for Dean
Awang Had Salleh Graduate School of Arts and Sciences
UUM College of Arts and Sciences

ZAMAILI BIN MAHAMUD
Penolong Kanan Pentadbiran
SMK Tun Perak,
33700 Padang Rengas, Perak.

Universiti Pengurusan Terkemuka
The Eminent Management University

Appendix C
Preliminary Study Questionnaires

UNIVERSITI UTARA MALAYSIA

KOLEJ SASTERA DAN SAINS

06010 SINTOK KEDAH DARUL AMAN

PENYELIDIKAN

Buku Teks Sains Tertingkat Menggunakan Realiti Luasan (eSTAR)

Enhanced Science Textbook Using Augmented Reality (eSTAR)

Pelajar-pelajar yang saya hormati,

Saya seorang pelajar Universiti Utara Malaysia dan kini sedang mengikuti Sarjana Sains (Pengajian Multimedia) secara Penyelidikan. Saya sedang menjalankan satu kajian awal di kalangan pelajar Tingkatan 2 untuk mengenal pasti isu-isu yang berkaitan dengan pendekatan pembelajaran Sains sedia ada di Malaysia. Semua maklumat daripada kajian ini hanya akan digunakan untuk tujuan akademik semata mata. Kerjasama anda amat dihargai.

Terima Kasih.

Penyelidik.

BAHAGIAN A:

Maklumat Peribadi

Jawab soalan berikut dengan menandakan (√) di dalam kotak dan ruangan yang disediakan.

1. Jantina:
   - ☐ Lelaki
   - ☐ Perempuan

2. Umur: ____ tahun

3. Bangsa:
   - ☐ Melayu
   - ☐ Cina
   - ☐ India
   - ☐ Lain-lain

4. Kelas Anda: ____________________

5. Adakah anda mempunyai komputer riba dengan webcam?
   - ☐ Ya
   - ☐ Tidak

6. Adakah anda mempunyai kemudahan internet di rumah?
   - ☐ Ya
   - ☐ Tidak

7. Berapa kerap anda mengguna internet?
   - ☐ Harian
   - ☐ Mingguan
   - ☐ Bulanan
   - ☐ Tidak pernah

BAHAGIAN B:

Persepsi Pelajar

Jawab soalan berikut dengan menandakan (√) di dalam kotak yang disediakan.

1. Adakah anda berminat dengan matapelajaran Sains?

   ☐ Ya ☐ Tidak

2. Adakah pembelajaran Sains di dalam kelas menarik dan menyeronokkan?

   ☐ Ya ☐ Tidak

3. Adakah buku teks Sains anda menarik?

   ☐ Ya ☐ Tidak

4. Adakah anda suka mempelajari sains menggunakan buku teks?

   ☐ Ya ☐ Tidak

5. Adakah anda merujuk kepada bahan pembelajaran tambahan selain daripada buku teks Sains?

   ☐ Ya ☐ Tidak

   Sekiranya jawapan anda **Tidak** maka terus menjawab soalan 7.

6. Adakah bahan pembelajaran tambahan tersebut dalam bentuk buku bercetak?

   ☐ Ya ☐ Tidak

7. Adakah anda menggunakan internet untuk mendapatkan bahan pembelajaran tambahan bagi Sains?

   ☐ Ya ☐ Tidak

8. Adakah penggunaan bahan pembelajaran tambahan bagi Sains dalam bentuk video dan animasi dapat menambah minat anda untuk mempelajari Sains?

☐ Ya ☐ Tidak

9. Adakah anda pernah melakukan ujikaji dalam makmal sains?

☐ Ya ☐ Tidak

10. Adakah anda boleh memahami sesuatu konsep sains dengan mudah melalui ujikaji?

☐ Ya ☐ Tidak

11. Adakah anda inginkan perubahan dalam kaedah pembelajaran sains?

☐ Ya ☐ Tidak

Appendix D

Learning Performance Evaluation (Pre-test and Post-test)

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

Para Pelajar yang dihormati,

Soal selidik ini dijalankan untuk mendapatkan maklumat berkaitan pemahaman anda tentang pembelajaran Sains melalui eSTAR.

Oleh itu, saya amat berbesar hati sekiranya anda dapat menjawab SEMUA soalan pada ruangan yang disediakan. Segala maklumat yang diberikan hanyalah untuk tujuan akademik.

Kerjasama anda amatlah dihargai. Terima kasih.

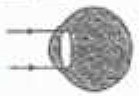
1 Seorang pelajar makan beberapa jenis makanan dan didapati bahagian lidah *X*, *Y*, dan *Z* pada Rajah 1 terangsang.

Rajah 1

Antara berikut, yang manakah jenis-jenis makanan yang dimakan oleh pelajar itu?

A Gula-gula, coklat, dan oren
B Madu, lemon, dan garam biasa
C Limau, cuka, dan garam biasa
D Gula-gula, cuka, dan oren

2 Rajah 2 menunjukkan satu keratan membujur mata yang mengalami kecacatan penglihatan.



Rajah 2

Antara berikut, yang manakah menyebabkan kecacatan penglihatan itu?

A Bola mata terlalu pendek
B Bola mata terlalu panjang
C Kanta mata terlalu nipis
D Saiz anak mata terlalu kecil

3 Rajah 3 menunjukkan keratan membujur mata manusia.

Rajah 3

Apakah fungsi *P*?

A Memfokus sinar cahaya
B Mengawal saiz anak mata
C Mengesan rangsangan cahaya
D Membenarkan cahaya masuk ke dalam mata

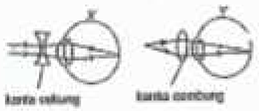
4 Rajah 4 menunjukkan laluan impuls apabila kulit menerima rangsangan.

Rajah 4

Antara berikut, yang manakah mewakili *P* dan *Q*?

	P	*Q*
A	Otak	Efektor
B	Reseptor	Otak
C	Efektor	Reseptor
D	Reseptor	Efektor

5 Rajah 5 menunjukkan dua jenis kecacatan mata.



Rajah 5

Apakah jenis kecacatan mata yang diwakili oleh *X* dan *Y*?

	X	*Y*
A	Rabun jauh	Rabun dekat
B	Astigmatisma	Rabun dekat
C	Rabun dekat	Rabun jauh
D	Rabun jauh	Astigmatisma

6 Antara organ deria berikut, yang manakah dapat mengesan bahan kimia?

A Mata dan hidung
B Lidah dan kulit
C Hidung dan lidah
D Hidung dan telinga

7 Maklumat di bawah menunjukkan fungsi struktur *X* dan *Y* bagi telinga manusia.

> *X*: Menguatkan getaran bunyi
> *Y*: Menghantar impuls saraf ke otak

Apakah yang mewakili struktur *X* dan *Y*?

	X	*Y*
A	Gegendang telinga	Saraf auditori
B	Osikel	Salur auditori
C	Salur auditori	Osikel
D	Osikel	Saraf auditori

8 Maklumat di bawah menunjukkan sejenis gerak balas tumbuhan terhadap rangsangan tertentu.

> • Pucuk tumbuh ke arah rangsangan itu
> • Membolehkan tumbuhan memperoleh cahaya matahari
> • Akar tumbuh menjauhi rangsangan itu

Antara berikut, yang manakah rangsangan itu?

A Fototropisme
B Geotropisme
C Tigmotropisme
D Hidrotropisme

9 Rajah 6 menunjukkan struktur kulit manusia.

Rajah 6

Antara bahagian A, B, C, dan D, yang manakah reseptor tekanan?

10 Antara berikut, yang manakah menunjukkan pembiasan cahaya yang betul bagi sinar cahaya yang bergerak dari udara ke air?

A


B


C


D

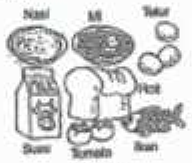

1 Vitamin *X* mempunyai ciri-ciri berikut:

- Mencegah skurvi
- Memelihara kesihatan kulit
- Terdapat dalam limau

Berdasarkan maklumat yang diberi, apakah vitamin *X*?

A Vitamin A
B Vitamin B
C Vitamin C
D Vitamin D

2 Rajah 1 menunjukkan contoh-contoh makanan.



Rajah 1

Kumpulan makanan yang manakah mengandungi kandungan karbohidrat yang tinggi?

A Susu, tomato, ikan
B Nasi, roti, mi
C Telur, roti, ikan
D Ikan, telur, nasi

3 Rajah 2 menunjukkan satu eksperimen yang dijalankan untuk mengkaji penyerapan bahan melalui tiub Visking.

Rajah 2

Air suling diuji pada akhir eksperimen. Antara yang berikut, yang manakah keputusan bagi eksperimen ini?

	Ujian kanji	Ujian glukosa
A	Ada	Tiada
B	Tiada	Ada
C	Tiada	Tiada
D	Ada	Ada

4 Antara proses berikut, yang manakah menyebabkan pergerakan makanan melalui usus?

A Asimilasi
B Respirasi
C Peristalsis
D Pencernaan

5 Antara pasangan kelas makanan dan contoh makanan berikut, yang manakah betul?

	Kelas makanan	*Contoh*
A	Lemak	Nasi
B	Protein	Jagung
C	Karbohidrat	Susu
D	Pelawas	Nanas

6 Jadual 1 menunjukkan tiga jenis makanan dan nilai kalori dalam 100 g makanan itu.

Jenis makanan	Nilai kalori/kJ
Nasi	1500
Telur ayam	700
Pisang	350

Jadual 1

Seorang pelajar bersarapan pagi dengan mengambil makanan seperti yang ditunjukkan di bawah.

- 200 g nasi
- 100 g telur ayam
- 50 g pisang

Berdasarkan Jadual 1, hitungkan nilai kalori yang telah diambil oleh pelajar itu untuk sarapan paginya.

A 1275 kJ
B 2375 kJ
C 2550 kJ
D 3875 kJ

7 Rajah 3 menunjukkan seorang lelaki yang menghadapi sejenis penyakit.

Rajah 3

Kekurangan nutrien yang manakah menyebabkan penyakit itu?

A Iodin
B Vitamin C
C Kalsium
D Protein

Soalan 8 dan 9 adalah berdasarkan Rajah 4.

8

Rajah 4

Antara berikut, yang manakah dicerna dalam organ *P* dan *Q*?

	P	*Q*
A	Protein	Lemak
B	Lemak	Karbohidrat
C	Karbohidrat	Protein
D	Lemak	Protein

9 Antara berikut, yang manakah fungsi bahagian *R* dan *S*?

	R	*S*
A	Menyimpan hempedu	Mencerna lemak
B	Mencerna kanji	Mencerna protein
C	Menghasilkan hempedu	Mencerna kanji
D	Mencerna protein	Menghasilkan hempedu

10 Jadual 2 menunjukkan pemerhatian bagi ujian yang telah dijalankan ke atas suatu sampel makanan.

Ujian makanan	Pemerhatian
Larutan Benedict dicampurkan kepada sampel makanan dan dipanaskan	Mendakan merah bata terbentuk
Beberapa titik larutan iodin dititiskan ke atas sampel makanan	Warna biru tua terbentuk

Jadual 2

Sampel makanan itu mengandungi

A lemak dan kanji
B protein dan lemak
C protein dan kanji
D glukosa dan kanji

Appendix E

AR Motivation Questionnaire

UNIVERSITI UTARA MALAYSIA

KOLEJ SASTERA DAN SAINS

06010 SINTOK KEDAH DARUL AMAN

PENYELIDIKAN

Buku Teks Sains Tertingkat Menggunakan Realiti Luasan (eSTAR)

Enhanced Science Textbook Using Augmented Reality (eSTAR)

Pelajar-pelajar yang dihormati,
Saya pelajar Universiti Utara Malaysia dan kini sedang mengikuti pengajian Sarjana Sains (Pengajian Multimedia) secara Penyelidikan. Saya sedang menjalankan satu kajian untuk menentukan keupayaan teknologi Realiti Luasan dalam meningkatkan motivasi pelajar bagi matapelajaran Sains. Kajian saya melibatkan pelajar Tingkatan Dua. Semua maklumat yang diperolehi daripada kajian ini akan hanya digunakan untuk tujuan akademik semata-mata. Kerjasama anda dalam menjawab soal-selidik ini sangat dihargai.
Sekian, terima kasih.

Yang benar,

Valarmathie Gopalan (813615)
MSc. MM Studies (by Research)

Bahagian A:

Maklumat Peribadi

Sila jawab soalan berikut dengan menandakan (√) di dalam kotak dan ruangan yang disediakan.

1. Jantina:

☐ Lelaki ☐ Perempuan

2. Umur: _____ tahun

3. Bangsa:

☐ Melayu ☐ Cina

☐ India ☐ Lain-lain

4. Kelas Anda: ______________________

5. Adakah anda mempunyai komputer riba dengan webcam?

☐ Ya ☐ Tidak

6. Adakah anda mempunyai kemudahan internet di rumah?

☐ Ya ☐ Tidak

7. Berapa kerap anda mengguna internet?

☐ Harian

☐ Mingguan

☐ Bulanan

☐ Tidak pernah

8. Pernahkah anda mengetahui tentang teknologi Realiti Luasan?

☐ Ya ☐ Tidak

Bahagian B:

Persepsi Pelajar

Sila jawab soalan berikut dengan membulatkan diruang yang disediakan mengikut skala seperti dalam jadual di bawah .

Sangat tidak setuju	Tidak setuju	Agak Setuju	Setuju	Sangat setuju
1	**2**	**3**	**4**	**5**

BIL	KENYATAAN	SKALA				
KEMUDAHGUNAAN / EASE OF USE						
1	Aplikasi eSTAR senang digunakan.	1	2	3	4	5
2	Matapelajaran sains sesuai untuk dipelajari menggunakan aplikasi eSTAR.	1	2	3	4	5
3	Aplikasi eSTAR sesuai digunakan untuk mengulangkaji sains.	1	2	3	4	5
4	Teknologi Realiti Luasan senang digunakan secara sendirian.	1	2	3	4	5
5	Langkah-langkah menggunakan aplikasi eSTAR adalah mudah diingati.	1	2	3	4	5
6	Teknologi Realiti Luasan memudahkan proses mengulangkaji matapelajaran sains.	1	2	3	4	5
PENGLIBATAN / ENGAGING						
1	Aplikasi eSTAR menarik minat saya untuk meneruskan mempelajari sains untuk jangka masa yang panjang.	1	2	3	4	5
2	Aplikasi eSTAR membuatkan saya mengulangkaji Sains berulang kali.	1	2	3	4	5
3	Aplikasi eSTAR menyebabkan saya melibatkan diri dalam pembelajaran sains untuk jangka masa panjang.	1	2	3	4	5
4	Teknologi Realiti Luasan meningkatkan penglibatan diri saya dalam pembelajaran sains.	1	2	3	4	5
KENIKMATAN/ENJOYMENT						
1	Sangat suka dan menikmati aplikasi eSTAR dalam mempelajari sains.	1	2	3	4	5
2	Aplikasi eSTAR membuatkan keunikan sains dinikmati secara mendalam.	1	2	3	4	5
3	Saya menikmati pembelajaran sains dengan menggunakan aplikasi eSTAR.	1	2	3	4	5
4	Teknologi Realiti Luasan memupukkan minat dalam saya dalam pembelajaran sains.	1	2	3	4	5
SERONOK/FUN						
1	Aplikasi eSTAR sangat seronok untuk digunakan dalam pembelajaran sains.	1	2	3	4	5

2	Isi kandungan aplikasi eSTAR menambahkan keseronokan dalam pembelajaran sains.	1	2	3	4	5
3	Saya seronok menggunakan aplikasi eSTAR dalam mengulangkaji sains.	1	2	3	4	5
4	Penggunaan aplikasi eSTAR adalah seronok untuk meneruskan pembelajaran saya berbanding dengan penggunaan buku teks biasa.	1	2	3	4	5
MOTIVASI/MOTIVATION						
1	Aplikasi eSTAR senang untuk digunakan.	1	2	3	4	5
2	Aplikasi eSTAR meningkatkan penglibatan saya dalam pembelajaran sains.	1	2	3	4	5
3	Saya menikmati proses pembelajaran sains untuk jangka masa yang lama.	1	2	3	4	5
4	Pembelajaran sains menjadi lebih seronok dengan menggunakan aplikasi eSTAR.	1	2	3	4	5
5	Aplikasi eSTAR meningkatkan motivasi saya untuk mencapai tahap cemerlang dalam sains.	1	2	3	4	5
6	Aplikasi eSTAR mendorong saya untuk meneruskan pengajian tinggi dan kerjaya yang berkaitan dengan sains pada masa hadapan.	1	2	3	4	5

Terima Kasih atas kerjasama anda.

Appendix F

Snapshots (Using eSTAR)

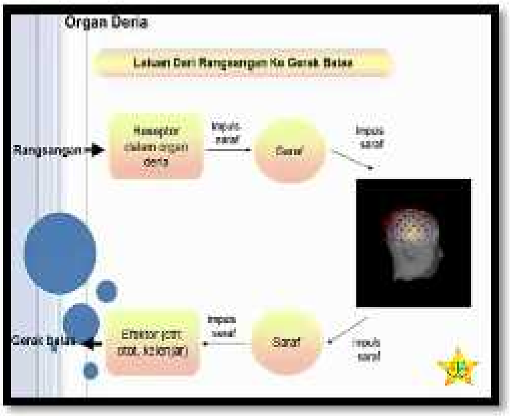
Appendix G

Snapshots (Pre-test and Post-test)

Appendix H

Snapshots of eSTAR Prototype

Chapter one: The World through Our Senses(Sensory Organs & Functions)



Chapter Two: Nutrition (Classes of Food)

KARBOHIDRAT

PROTEIN

LEMAK

PELAWAS

AIR

VITAMIN

MINERAL

Food Testing

Human Digestive system

Information (Only Audio Display)

INFO 1

INFO 2

Quiz

If answered right answer

If answered wrong answer

Appendix I

Experts Profile

Dr. Juliana Aida Abu Bakar is a senior lecturer at the Multimedia Technology and Communication, Universiti Utara Malaysia (SMMTC). Her research areas comprise Virtual Environment Technology, Augmented Reality and Learning and Multimedia Learning Environment.

Mohd Fitri Yusoff is a lecturer at the School of Multimedia Technology and Communication, Universiti Utara Malaysia (SMMTC). His research areas include Virtual Environment Technology, Augmented Reality and Learning, Multimedia Learning Environment, Persuasive Multimedia, Design and Development.

Sabariah Othman is a teacher at the Clifford Secondary School, Kuala Kangsar, Perak. She has experience in teaching science subject for form two for more than five years.

Roszilah Bassin is a senior teacher of science and mathematics at the Tun Perak Secondary School, Padang Rengas, Perak. She has experience in teaching science for more than five years.

Appendix J

Experts Reviews 1

EVALUATION BY INTERFACE EXPERT

I, hereby certify that the **Enhanced Science Textbook Based on Augmented Reality (e-STAR)** has been produced by Valarmathie Gopalan (813615), student of Master of Science (Multimedia Studies) by Research, College of Arts and Sciences, Universiti Utara Malaysia. It has been checked in terms of the validity of the contents and the general comments are as follows:

General Comments:

① 'Panduan Pengguna' must be a step-by-step guide to use the AR app.
All explanation related to the app should be moved to new page of 'Introduction to e-STAR'.
② One video has spelling error. The app should be error free.
③ Technical glitch exists. This may refrain the user to use the app.

Name: ____________________
Position: ____________________
Address: ____________________

DR. JULIANA AIDA ABU BAKAR
Senior Lecturer
School of Multimedia Technology and Communication
UUM College of Arts and Sciences (CAS)
Universiti Utara Malaysia

Date: 15 Dec 2014

Appendix K

Experts Reviews 2

EVALUATION BY INTERFACE EXPERT

I, hereby certify that the **Enhanced Science Textbook Based on Augmented Reality (e-STAR)** has been produced by Valarmathie Gopalan (813615), student of Master of Science (Multimedia Studies) by Research, College of Arts and Sciences, Universiti Utara Malaysia. It has been checked in terms of the validity of the contents and the general comments are as follows:

General Comments:

1. All the markers should be in same size
2. Standardise the marker illustration either with the real images or the cartoon images
3. Technical glitches are available and it might stop the users from continuing this apps

Name: MOHD FITRI YUSOFF

Position: LECTURER.

Address: SMMTC, UUM.

Date: 15/12/14.

Appendix L

Experts Reviews 3

EVALUATION BY CONTENT EXPERT

I, hereby certify that the **Enhanced Science Textbook Based on Augmented Reality (e-STAR)** has been produced by Valarmathie Gopalan (813615), student of Master of Science (Multimedia Studies) by Research, College of Arts and Sciences, Universiti Utara Malaysia. It has been checked in terms of the validity of the contents and the general comments are as follows:

General Comments:

Bahan ini telah disemak dan sesuai utk. kegunaan pelajar. Harap bahan Pembelajaran seperti ini dapat digunakan dalam mata pelajaran lain.

Teruskan Usaha!

Name: SABARIAH OTHMAN

Position: GURU

Address: SMK CLIFFORD KUALA KANGSAR
33009 KUALA KANGSAR
PERAK

Date: 14/11/2014

Appendix M

Experts Reviews 4

EVALUATION BY CONTENT EXPERT

I, hereby certify that the **Enhanced Science Textbook Based on Augmented Reality (e-STAR)** has been produced by Valarmathie Gopalan (813615), student of Master of Science (Multimedia Studies) by Research, College of Arts and Sciences, Universiti Utara Malaysia. It has been checked in terms of the validity of the contents and the general comments are as follows:

General Comments:

Bahan pembelajaran yang disediakan sangat menarik dan dapat membantu memotivasikan serta meningkatkan minat pelajar dalam mata pelajaran Sains.
Isi kandungan bahan amat bersesuaian dan boleh diaplikasikan dalam pdp.

Penghasilan bahan pdp seperti ini diharap dapat diperluaskan untuk mata pelajaran - mata pelajaran lain.

Tahniah diucapkan kepada Saudari Valarmathie a/p Gopalan di atas usaha gigih beliau menghasilkan bahan pdp yang sangat bermanfaat.

Name: ROSZILAH BT. BASSIN

Position: GURU KANAN SAINS DAN MATEMATIK

Address: SMK TUN PERAK
33700 PADANG RENGAS,
PERAK.

Date: 17/11/14