Faculty of Cognitive Science and Human Development

AUGMENTED REALITY IN EDUCATION : CURRENT PROBLEMS AND SOLUTIONS

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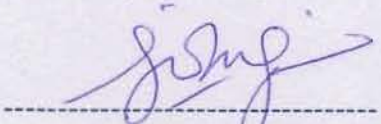

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ABSTRACT

AUGMENTED REALITY IN EDUCATION : CURRENT PROBLEMS AND SOLUTIONS

Norliza Ghazali

Generally, this project aims to perform a preliminary study into the current problems and solutions of Augmented Reality (AR) in Education. Among the factors studied includes advantages and disadvantages when applying AR in Education and differences between AR and Virtual Reality (VR) in Chemistry, Mathematics Geometry, Astronomy and Geography in terms of its strength and weaknesses. Five case studies had been designed to study each of these approaches applications. The problems and solutions are gathered from literature reviews in order to have accurate value for enhance knowledge and information to others. This technique is called "case study" which gives freedom to give comments and give relevant suggestions according to the past researches. Most of the resources are gathered from the internet and Unimas' library which is known as Centre of Academic and Information Services (CAIS). The techniques that had been used are collecting data, selecting sources, extracting or chunking the relevant information, comparing and discussing based on the previous researches and make conclusion from it. Through the study, it was found that there are more VR applications than AR applications especially in education. It is because AR designers have to consider association between real and virtual scene. On the other hand, VR systems just involved with virtual environment only. Furthermore, AR approaches can enhance communications and interactions between students and teachers. However VR in Astronomy has proven that VR systems can also work in collaboration in order to achieve the same missions or goals. Besides that, these technologies may also increase students' interest to learn sciences and mathematics subjects. The advantages of implementing these both systems – VR and AR in Education is it can provide valuable information and create safe environments to users for exploring the complex and dangerous experiments or concepts. Furthermore based on findings, AR in Education is the best compared to VR in Education even though both have it own strengths and limitations. As a conclusion, this study had revealed the differences, advantages and disadvantages between AR and VR in Education that be applied in Chemistry, Mathematics Geometry, Astronomy and Geography in order to improve the future developments.

ABSTRAK

AUGMENTED REALITY DALAM PROSES PEMBELAJARAN : PERMASALAHAN DAN PENYELESAIAN PADA MASA KINI

Norliza Ghazali

Pada umumnya kajian ini bertujuan untuk melakukan kajian awal terhadap permasalahan dan penyelesaian pada masa kini yang berkaitan dengan Augmented Reality (AR) dalam proses pembelajaran. Faktor-faktor yang telah dikaji termasuklah kelebihan dan kelemahan dalam melaksanakan AR dalam proses pembelajaran serta perbezaan di antara AR dan Realiti Maya dalam aplikasi Kimia, Matematik Geometri, Astronomi dan Geografi. Terdapat lima kajian kes telah dijalankan untuk menyelidik setiap aplikasi sistem yang telah dibangunkan. Permasalahan dan penyelesaian ini telah dikumpul melalui pembacaan kajian-kajian lepas bagi memberi maklumat yang tepat untuk membantu orang lain meningkatan pengetahuan dan menambahkan maklumat yang sedia ada. Kaedah ini dikenali sebagai kajian kes di mana ia memberi kebebasan untuk memberi komen dan pendapat berdasarkan kajian-kajian lepas. Kebanyakkan maklumat ini diperolehi dari internet dan perpustakaan Unimas yang lebih dikenali sebagai Pusat Khidmat Maklumat Akademik (PKMA). Teknik-teknik yang digunakan merangkumi pengumpulan data, pemilihan maklumat, mengambil dan memendekkan petikan yang berkaitan, membandingkan dan membincangkan maklumat berdasarkan kajian-kajian lepas serta membuat kesimpulan mengenainya. Melalui kajian ini, dapatan telah menunjukkan bahawa aplikasi Realiti Maya lebih banyak berbanding AR terutamanya dalam proses pembelajaran. Hal ini kerana pencipta-pencipta sistem AR perlu menitik beratkan gabungan di antara persekitaran sebenar dan maya. Sebaliknya, sistem Realiti Maya hanya melibatkan persekitaran maya sahaja. Tambahan pula, pendekatan AR ini boleh meningkatan komunikasi dan interaksi di antara para pelajar dan guru-guru. Bagaimanapun, Realti Maya yang diaplikasi dalam Astronomi telah membuktikan bahawa sistem Realiti Maya juga boleh digunakan untuk kerja yang melibatkan kerjasama di antara pengguna-pengguna bagi mencapai misi yang telah ditetapkan. Selain itu, teknologi-teknologi ini juga boleh meningkatkan minat para pelajar dalam mempelajari subjek ilmu sains dan matematik. Kelebihan pelaksanaan kedua-dua sistem ini (AR dan Realiti Maya) adalah dari segi kebolehannya memberi penerangan yang terperinci dan memberi persekitaran yang selamat kepada pengguna untuk menjalankan eksperimen atau konsep yang kompleks dan merbahaya. Tambahan lagi, berdasarkan kajian didapati bahawa AR dalam proses pembelajaran lebih baik daripada Realiti Maya. Kesimpulannya, kajian ini telah mengenalpasti perbezaan, kelebihan dan kelemahan di antara AR dan Realiti Maya dalam proses pembelajaran yang telah diaplikasikan dalam subjek Kimia, Matematik Geometri, Astronomi dan Geografi bagi meningkatkan penciptaan sistem-sistem ini di masa hadapan.

CHAPTER 1

INTRODUCTION

1.0 Introduction

This project will discuss about the background of the research which help readers to know and understand what this study is all about. Overall, this project consists of problem statement, research question that lead to this study, research objectives, limitations that occur during this research is done, strengths of the study and structure of the thesis.

1.1 Background of Research

This research is a study of Augmented Reality (AR) in Education in terms of its current problems and solutions. AR could help students to memorise better

and can attract them to further their study by using interesting and interactive graphical visual teaching approach. As Hunt & Ellis (2004) mentions, "particular processes such as imagery; self-referent encoding and self- generation can enhance memorization". For an example in our daily life, we can easily remember someone's face rather than their names. Besides that, AR also provide safe, attractive and informative environment to users. This is because AR is only involves in the interaction between users and computer. Furthermore, AR could also increase communication among users. As we all know, human cannot avoid from society interaction due to being interdependent between each other, such as for getting and giving love, share problems, etc. This strength makes AR to be more valuable to be applied in education. This is because the educational system is part of society and these relationships have a strong effect on what schooling can achieve (Long, 2000). As a result, it may increase student's creativity and productivity.

Besides that, this paper will also discuss about Virtual Reality (VR) in Education that will be applied in Chemistry, Mathematics Geometry, Astronomy and Geography in terms of it strengths and weaknesses. As Briggs (1996) says,

"Virtual reality can be defined as a three-dimensional, computer-generated simulation in which one can navigate around, interact with, and be immersed in another environment. In this sense, "virtual" is derived from the concept of "virtual memory" in a computer, which acts "as if" it is actual memory. Virtual Reality provides a reality that mimics our everyday one."

Furthermore, according to Seidel & Chatelier (1997), VR would be defined as 'human immersion in a synthetic environment' due to the implication of total presence within the simulation itself in order to determine what the virtual environment or virtual reality is. Greimel, Fuhrmann, & Kaufmann (2001) emphasizes that "A simulation must therefore represent a (conceivably) real situation and must be dynamic."

VR could also contribute some advantages to students. As Winn (2002) says,

"Working at the University of Washington's Human Interface Technology Laboratory, in collaboration with scientists from the UW PRISM project, has built a complete three-dimensional "virtual world" that encompasses Puget Sound, from Admiralty Inlet to Tacoma. Visitors to Virtual Puget Sound can fly or swim anywhere they want. At certain points, they can do what JoAnn (in a computer-created "virtual world".) is doing, such as measure properties of the marine environment, stop time, choose whether the tide is high, low or somewhere in between, set currents to be shown as arrows, or release particles and see where the tide will take them."

As a result, it may encourage students to 'feel' and 'see' the real situation in order to have better understanding about the project.

As a conclusion, this study will concentrate or focus on the advantages and disadvantages of AR and VR in Education and the differences between AR and VR that is being applied in Chemistry, Mathematics Geometry, Astronomy and Geography in terms of its strengths and weaknesses. This study may lead to supplement in Malaysian education, such as decreasing absence rates in the class,

producing creative students, etc because AR can give safe, interactive and informative environment to students.

1.2 Problem Statements

Education is part and parcel of our life. Each day we learn new techniques or experiences, in addition we can learn more about our environment and how to deal with our society. Due to this opinion, researchers came up with an idea by applying AR in Education. According to Dickinson (2000), "educators everywhere face similar problems and reaching similar conclusions about potential solution."

First, there is less of information in AR in Education especially in Third World such as Africa and developing countries such as Malaysia, Thailand, etc. Because of this, the researchers will face a problem to study it in order to apply and use AR in most fields. They also have to determine how to make AR to become more interesting and interactive information with low cost, so that most schools could use it. As we all know, from better learning we can produce creative generation for future.

Even though AR and VR are attractive but it also has problems in terms of learning and teaching. Students sometimes feel bored even if they have advanced educational technology. As Morineau, Gorzerino, & Papin (1997) mentions, "Wickens (1992) argues that a task performed with kind of advanced user interface would produce a long term retention decrease in memory, despite an

augmentation of performance level in situation." In addition Morineau, Gorzerino, & Papin (1997) also points out that "cognitive process required will not be satisfied to form mental links between representation of information to be learnt due to decreasing cognitive effort and it may be caused by visualisation of abstract concepts which is not natural." Because of this, we should find a technique that can attract those students to study more seriously by considering their perspective and the way they think. Besides that, this high technology also have to be improved in terms of it usability and to be more user-friendly.

In addition, recently Malaysia educational system is facing the problems of increasing absence rates among students. This problem had been shown in NTV7 program called 'Edisi Siasat' in 2004. Those students spent their 'school hours' at games centre or loafing with others who play truant too. Maybe those students will be attracted to come to school when AR and VR are applied in education. It is because graphical aspect that is being used in AR and VR which make them 'feel' and 'see' the situation could enhance their understanding about the topic of study.

Besides that, we also have to determine why AR cannot be applied in various fields and try to find solutions for it. If we can make this dream come true, maybe we can produce a lot of creative person in all kind of fields. Furthermore, we should also find a way to make AR applied in various places, so that we can decrease the feeling of boredom among students. It is because, based on my observation; most AR systems are built in laboratory due to the big equipments that have been used.

As a conclusion, these problems should be solved, so that AR can be applied

in Malaysia around this corner as a supplement to the educational system. But the limitations on resources makes this aim become slower than it should be.

1.4 Research Questions

This research is intended to study the current problems of AR in Education and their solutions. Below are the research questions :

i. How to produce better education for society?

ii. What are the possibilities of implementing AR in Education for Malaysia context?

iii. How to make this implementation become reality?

iv. How to improve AR to become more interesting?

1.5 Research Objectives

Generally, the aim of this research is to study the problems of AR in Education and how to solve it. The exploration will get a lot of essential information that can give new creative ideas for future. Thus, the specific objectives of the study are :

i. To find more current problems and solutions for AR in Education.

ii. To identify the advantages and disadvantages when applying AR in Education.

iii. To find differences between AR and VR in Chemistry, Mathematics Geometry, Astronomy and Geography in terms of its strength and weaknesses.

1.6 Value of Study

Recently, researchers found new ways to teach students in interactive and informative approach which is called AR in Education. For example, research by Billinghurst (2003) suggests that "they (users) look at the pages (MagicBook) through a handheld Augmented Reality display in order to make them see three-dimensional virtual models appearing out of the pages". This interactive and enjoyable approach could attract students to come to class, in order to reduce absence rates among students.

Figure 1.0 : Augmented Reality in Education. [Billinghurst, 2003].

This research gives an opportunity to contribute more information for AR in Education for others, especially for Malaysian context. It is because Malaysia still

lacks information in AR. In addition, not much research is being done in this area in Malaysia. It is due to the lack of expertise. If more research in AR can be done, Malaysia could apply it in most fields that suite to the Malaysia context.

In addition, we could improve our educational system by using AR and VR in Education as a supplement. As we all know, AR and VR can make changes in education because we could encourage students to create or formulate their own theory by allowing them to keep control the system. For example, Winn (2002) observes that "Virtual worlds built at George Mason University allow students to use their hands to directly manipulate source charges in electromagnetic fields, and atoms and bonds in organic molecules. Students can become a ball and experience, first hand, Newton's laws of motion." As a result, it could encourage students to use their creativity by manipulating the system in order to see the result either good or bad which could not be done in real world. It is because most of science subjects involved with dangerous items.

Besides that, AR can enhance the teaching and learning process, such as providing safe, interactive and informative environment to the students. Therefore, teachers can motivate students to increase their interest in their studies and can decrease absence rates in classes. For instance a study by Liarokapis, Petridis, Lister & White (2003) called Multimedia augmented reality interface for e-learning (MARIE) found that MARIE allow the teacher speak to the student at the same time where the user listens to the wav file. The two sound sources are mixed together in the system. Figure 1.1 showed interaction and collaboration between non-immersed users (those that do not wear HMD) with the immersed user through the monitor and voice.

Figure 1.1 : Multimedia augmented reality interface for e-learning (MARIE). [Liarokapis, Petridis, Lister & White, 2003].

1.7 Significance of the Study

Based on my findings, it was found that there are more VR applications than AR applications especially in education. It is because AR designers have to consider association between real and virtual scene. On the other hand, VR systems just involved with virtual environment only.

AR and VR is almost the same in terms of interaction among users in attractive ways by using the graphics virtual objects, creating a safe environment and providing valuable information to users. Through the study, the differences between AR and VR can be divided into four categories – interaction, scene, equipment and technique.

In case study 1, the result showed that AR and VR in Chemistry expose users to complex cases or experiments in order to increase better understanding about the complex explanation. On the other hand, in case study 2, the result indirectly showed that AR and VR in Mathematics Geometry could increase students' interest to learn Mathematics where they (users) can freely move around in order to manipulate the virtual environment. In case study 3, the result showed that AR in Astronomy focused more to increase communication between students and teacher in order to attract students to love and understand the astronomy subject. In case study 4, the result showed that AR in Geography has been developed for outdoor and indoor activities in order to increase users' understanding in the real world application.

However, the results obtained in this study are strictly applied in these particular field applications and could not be generalized to others VR and AR application.

1.8 Limitations of the Study

This thesis has a few weaknesses or limitations that are considerably unavoidable. This study is limited to five branches of educational field which focuses only on differences between AR and VR in Chemistry, Mathematics Geometry, Astronomy and Geography in terms of its strengths and weaknesses. In reality, many more educational fields can be studied.

Another limitation in this study is the difficulty of finding the AR and VR sources that is applied in education. It is because Malaysia still lacks information

in AR. In addition, Malaysia does little research in this area because lacks expertise. For example there are only few books in VR at Unimas' library (CAIS). So each cognitive science (CS) students and information technology (IT) students have to compete with each other in order to lend it first.

1.9 Strengths of the Study

Instead limitations, this study has a few strengths that could be considered in the attempt to improve learning approach which work as a supplement in educational system. This study will discuss in detail the strengths and weaknesses between AR and VR that could be applied in education in terms of Chemistry, Mathematics Geometry, Astronomy and Geography. As a result, it can contribute ideas or suggestions as to what are some of the advantages and disadvantages between AR and VR for learning approach.

Besides that, this study may contribute more information for AR in Education for others especially for Malaysian context. It is because Malaysia still lacks information in AR due to little research in this area and lack of expertise. If more research in AR could be done, others and especially Malaysian can apply it in most fields in the future.

1.10 Structure of the thesis

Chapter 1 – This topic is called introduction which will discuss about background of the research which help readers to know and understand what this

study is all about. Overall, this topic consists of problem statement, research question that lead to this study, research objectives, limitations that occur during this research is done, strengths of the study and structure of the thesis.

Chapter 2 - This topic describes previous researches that have been used in this thesis as references and guidelines for coming out with new solutions or suggestions. It consists of research background about Augmented Reality (AR), Virtual Reality (VR), Augmented Reality (AR) in Education, Virtual Reality (VR) in Education, Augmented Reality (AR) in Chemistry, Virtual Reality (VR) in Chemistry, Augmented Reality (AR) in Mathematics Geometry, Virtual Reality (VR) in Mathematics Geometry, Augmented Reality (AR) in Astronomy, Virtual Reality (VR) in Astronomy, Augmented Reality (AR) in Geography and Virtual Reality (VR) in Geography.

Chapter 3 - This topic will discuss in detail about research methodology of the study. It consists of systematic steps for having an accurate value in order to enhance knowledge and information to others.

Chapter 4 – This topic will discuss the study's result based on comparing with previous sources or discussion with supervisor and friends in order to have the accurate solutions and to enhance knowledge about the research topic. This topic consists of advantages and disadvantages when applying AR in Education and differences between AR and VR in Chemistry, Mathematics Geometry, Astronomy and Geography.

Chapter 5 – This topic will justify the study based on the state of knowledge revealed in the literatures. This process has been done by using the

literatures suggestions about appropriate courses of action to try to solve the problems.

1.11 Conclusion

This topic could give an idea to others about what this research is all about. The subtopics are for recommendations or suggestions to readers so that they can use or jump to their interest topic. These subtopics come out from weaknesses and strengths that have been faced during this research is studied.

CHAPTER 2

RESEARCH BACKGROUND

2.0 Introduction

This topic describes previous researches that have been used in this thesis as references and guidelines for come out with new solutions or suggestions. According to McBury & White (2004), opinion of experts in the field will help to know more in detail about the topic. It helps to find out or locate other people's ideas that are related to this research problem, in order to evaluate these ideas in terms of their relevance to the research problem.

2.1 Research Background

2.1.1 Augmented Reality (AR)

AR is a part of Virtual Reality (VR) which allows a person to view one or more virtual 3D objects in the real-world environment (Shelton, 2002) due to combination of the real scene viewed by the user and a virtual scene generated by the computer, that augments the scene with additional information (Vallino, 2002) for assisting the user in his environment (Rhodes et al., 1999). The connection between AR and VR can be seen through Vallino (2002) who observes that,

"Milgram (Milgram & Kishino 1994; Milgram, Takemura et al. 1994) describes a taxonomy that identifies how augmented reality and virtual reality work are related (the amount of virtual imagery increases and the connection with reality weakens when it moving from left to right.)." The Reality-Virtuality continuum shown as Figure 2.0.

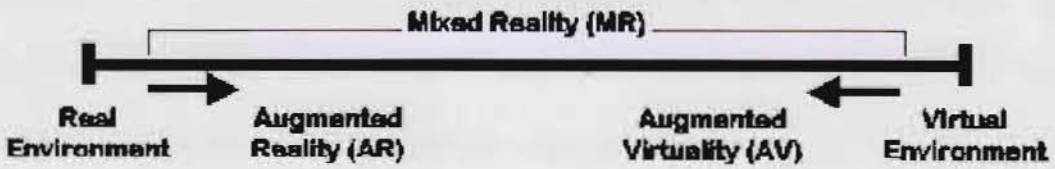

Figure 2.0 : Introduction to Augmented Reality. [Vallino, 2002].

Nowadays, the AR technology has been used in some fields such as education, manufacturing, entertainment and games due to valuable information, gives a lot of advantages to users and can enhance users' understanding of

subject's content. In addition Spohrer (1999) claims that "since the pioneering work of Ivan Sutherland in 1968, the vision of putting information in places has been a key goal of researchers developing AR systems." This may be due to the safe, interactive and informative environment that AR can give to users. For example of Yoshinori Kobayashi's (2000) work of AR practical called EnhancedDesk which allow users to perform several recognition tasks in an office environment which help people who have difficulties in using computer which is shown in figure 2.1.

Figure 2.1 : Augmented Reality Explained [Daly, 2004].

There are several strengths or advantages in applying AR in most fields. One of the advantages is it can provide informative environment to user, especially to students. For instance a research by Bimber, Encarnação & Schmalstieg (2003) called 'The Virtual Showcase as a new Platform for Augmented Reality Digital Storytelling' suggested that,

"The possibility to communicate information more effectively with digital means by telling stories that can be experienced directly within a real environment or in combination with physical objects. The user experience is thus transformed from relating different pieces of information to one another to 'living through' the narrative."

Figure 2.2 shows Virtual Showcase of paleontology demonstration in the Emerging Technology Laboratory at ACM Siggraph 2002.

Figure 2.2 : The Virtual Showcase as a new Platform for Augmented Reality Digital Storytelling. [Bimber, Encarnação & Schmalstieg, 2003].

Besides having advantages, AR also has some limitations or disadvantages. One of the limitations is user can easily get confuse with the real environment and the virtual objects. It is due to how information is captured and how they are registered. Mackay & Fayard (1999) says,

"Because of the potentials for confusion between the real and the virtual, augmented reality requires a multi-disciplinary approach, with a strong emphasis on the user. New technologies may offer fundamentally new ways of empowering users; but successful applications will have to be integrated into real-world activities."

This is a very basic problem because according to Spohrer (1999), combination of real and virtual images into a realistic composite is very challenging especially the task that needs a user to move around, since a tracker must be accurate to a small fraction of a degree in orientation and a few millimetres in position; otherwise the illusion of a virtual object in the real world

will be destroyed. However a research by Seichter (2004) suggested that the confusion could be reduced by dynamic content and mapping them sufficiently.

Besides that, AR is a big possibility that could lead to the problem of addiction because it has a high potential to take control of the users' mind. A study by Adams (2005) found,

"Augmented Reality technology holds the potential to be the darkest; most powerful system for mass control of the population ever invented in order to tune users in to experiential broadcasts created by corporations and centralized governments. As a result, it will likely be a system approaching "total mind control" due to unlimited control to make the virtual environment to seem real."

As a conclusion, currently AR is considered an advance technology compared to others. There are numerous and increasing studies and researches being done for AR application in most countries. As a result, it could be popular in most fields in future.

2.1.2 Virtual Reality (VR)

VR is a technology that gives opportunity to a user to interact with the system in a realistic way which allows user to be able to get inside to the situation or environment such as playing car race in games centre. Thus could make one to feel the situation as if one is racing in the real world (Mohd Shahrizal, 2003). As stated in VR notes:

"The term "Virtual Reality" was initially coined by Jaron Lainer, 1989." (Mohd Shahrizal, 2003)

VR can be applied in various fields, such as entertainment, military training, manufacturing, medical training, education, etc because it can gives valuable information and experience to users in an attractive environment from graphical aspect being used. According to National Research Council (1999),

"The earliest use of a computer-generated graphical display on a cathode ray tube (CRT) was in the Project Whirlwind, a project sponsored by the U.S. Navy to develop a general-purpose flight simulator. By the late 1940s, Robert Everett at the Massachusetts Institute of Technology (MIT) had developed a light gun that could cause the CRT to react. Researchers on SAGE, the successor to Whirlwind, made extensive use of interactive graphics consoles with displays equipped with a light gun capable of sending signals coordinated with the display. By 1955, U.S. Air Force personnel working on SAGE were using light guns for data manipulation."

This graphical aspect in VR could attract users, especially students to enjoy their learning and understand better complex information due to interaction between computer and user in real time. In addition, it could also attract them to be involved in each activity. For example, Smith (1995) found that a project called 'The Projectiles Experiment', which allows users to initialize velocity of the virtual cannon ball and the altitude of the cannon before firing it to free space. View of the system is shown as Figure 2.3.

Figure 2.3 : The Distributed Extensible Virtual Reality Laboratory [Smith, 1995].

However there is still having some problems or limitations with VR due to equipments that users must wear before proceeding to the VR world where a user would easily get tired a few minutes after wearing those equipments, etc. Pair & Piepol (2002) says "users are often required to wear bulky head mounted displays that restrict a person's freedom to physically move as they would in the real world. Furthermore, a person cannot touch or feel objects in the virtual world."

As a conclusion, VR and AR is almost the same but the main difference between these fields is VR is totally immersive (user fully interact with the computer only). Instead, AR can give more flexible interaction between information that is offered by computer and user perception; in order to make a combination of real environment and virtual scene.

2.1.3 Augmented Reality (AR) in Education

AR in Education allows users to experience a mixed reality and they can freely control the interface based on their decision. Kaufmann (2003) expresses

the view that "AR allows users to "keep control", to see the real world around them and to give the users the freedom of sight needed to move around." Therefore, students can enhance their creative knowledge without misinterpretation.

Recently, this educational technology has being used and studied in various countries such as New Zealand, America, etc. For example study by USA researchers Bimber, Encarnação & Schmalstieg (2003) which is called 'The Virtual Showcase as a new Platform for Augmented Reality Digital Storytelling' found that,

"The perceptual quality and the unique aura of a real environment (e.g., a historical site) or object (e.g., an ancient artifact) cannot be simulated by today's technology. Thus it is not possible to substitute them (user) with virtual or electronic copies without them losing their flair of originality."

Many countries have done a lot of research in that field too, so that the information could be used to correct and improve the system for the future use. This is because; AR in Education could help students to memorise better due to graphical visual that is being used in AR. Furthermore, user especially students will also be motivated to figure out how to adapt what they already learnt or knew to new challenges they confronted. As Shelton (2002) mentions students can enhance their cognitive path toward understanding of study's content by applying AR in education due to direct and clear information. However, it is difficult to ensure that each user clearly understands what others users point at or refer to,

since the graphics are overlaid independently on each user's view of the world (Azuma et al., 2001).

Besides that, Billinghurst (2003) has pointed out that the differences educational experience that is being offered by AR because of seamless interaction between real and virtual environments, the use of a tangible interface metaphor for object manipulation and the ability to transition between reality and virtuality smoothly.

Instead of advantages, there are several limitations when using AR in Education. The problem is users need to use AR devices which are highly costly such as Optical See-Through HMD, Video See-Through Augmented Reality Display, etc so that they can feel fully interactive AR environment. Berre et al. (2002) observes that, the AR machines are relatively expensive so that its use in industrial, military or well-founded academic projects are only limited. However, users who have limited financial can still use AR application by using usual computer with provided camera. These devices give less interactive in AR environment because the AR environment can only be seen in the computer. As Berre et al. (2002) mentions, both keyboard and mouse are designed with two-dimensional interaction in mind, but on the other hand AR is linked to a three-dimensional world. However in Billinghurts's (2003) view, AR interfaces can enhance the real world experience, compared to other computer interfaces that draw users away from the real world and onto the screen.

As a conclusion, AR in Education could give advantages to educational system in terms of increasing learning approach. So that, students are more

motivated to come to schools and can adapt what they already learnt or knew to new challenges they confront later, especially when they go to work.

2.1.4 Virtual Reality (VR) in Education

A study by Narayanan (1998) found that VR application in education could be divided into four categories. There are VR in Schools, VR in Technical Training, VR for Special Education and VR in Distance Education. This system allow students to walk through in the safety environment for understand better about the complex topic. In addition, Briggs (1996) observes that,

"One application from World Builder of Rochester, New York, allows trainees to walk through a virtual factory and learn about health hazards in more engaging experience than reading a manual or attending a lecture."

Besides that, VR in Education could also help students to memorise better due to graphical visual. It can encourage students to manipulate the information based on their perception about the topic. Furthermore, Briggs (1996) claims that, "Trainees in a wide variety of environment will be able to safely try out new techniques. They will be able to learn by doing tasks virtually before applying them in the real world. They will use these practice tasks in hazardous environments and also practice dealing with emergencies on the job."

This does not imply that Virtual Environments should replace all other teaching methods or media, but it is considered as a supplement in an effective and meaningful way by contributing to the students' understanding and learning. By letting the students to directly manipulate and experiment within the virtual

world, a higher level of elaboration is reached than just by reading a book or listening to the teacher. (Greimel, Fuhrmann, & Kaufmann, 2001)

On the other hand Kaufmann (2003) found that even though VR can contribute to raise interest and motivation in students with a high potential to enhance the learning experience but practically VR designers still has yet to explore and understand how to use VR technology to support learning activities.

Besides that, most VR application is being done at laboratory due to the big and expensive equipment which need extra care. There is much to be done to bring virtual reality to be fully applied into the classroom in order to bring traditional place in VR learning approach. As Jobe (2000) points out that,

"Diversity University was the first MOO to be designed specifically for classroom use. The Main Campus is a real time, virtual reality educational environment that's internet accessible. The virtual classrooms offer a student-cantered learning environment."

In addition, VR equipments also would affects student performance in terms of physiology position. According to Fiorentino et al. (2003), VR experimental test bed called SpaceXperiment has been used to prove that speed, limb position and direction can affect the user's interaction performance during pointing, picking and line sketching.

As a conclusion, VR in Education should be widely studied in various aspects in order to improve the system and to increase VR application in education.

2.1.5 Augmented Reality (AR) in Chemistry

By applying AR in Chemistry, we can encourage students to create their own formulate in safety environment because AR just involves computer. On the other hand, the older approach in studying chemistry exposure students to danger environment due to dangerous chemical. But they still give same result even though both are using different ways of teaching. In addition, Fjeld, Juchli & Vögtli (2003) found that,

"Ware & Rose (1999) says that when working with 3D virtual environments, users are cognitively challenged in understanding and knowing how their actions affect models."

One of the researches, Fjeld & Vögtli (2002) is called Augmented Chemistry (AC) which allows user to choose element from booklet menu, then it will be composed into 3D molecular models. Figure 2.4 shows booklet offering one element that is Na (scientific name), which known as sodium.

Figure 2.4 : Augmented Chemistry [Fjeld & Vögtli, 2002].

Furthermore, this stage can be seen in clearer view through some images from QuickTime movie which demonstrates the full functionality of AR. Image 1 showed the book on the right that contains all the elements including additional information. When user chooses an element from booklet for example Methylamin, it will display of molecules structure shown as Image 2. Image 3

showed that Augmented Chemistry lets user to define a specific chemical bond via the very old-fashioned, lego-style, tetrahedral model. The distances between the centre of the gripper and the four corners of the tetrahedron define via fuzzy-logic whether user is choosing a corner, an edge or a surface of the tetrahedron. This choice defines the bond strength. Each unsaturated atom offers such a tetrahedron and the possible bonds. On the other hand, Image 4 showed predefined molecules. User can rotate them and rebuild it based on ones interest. Augmented Chemistry will recognize or identify the molecules and show the definition while telling user something about its special properties via audio. (Vögtli, 2002)

Image 1

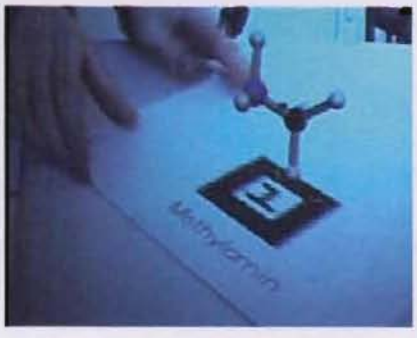

Image 2

Image 3

Image 4

Figure 2.5 : Augmented Chemistry: An Interactive Educational Workbench [Fjeld & Vögtli, 2002].

Augmented Chemistry (AC) project is one of the projects using marker based devices method. By using collision-detecting software AR toolkit can detect when the paddle object collides with another virtual – marker bound – object which also can provide interactivity to the system. (Berre et al., 2002)

It also has some limitations or weaknesses instead of AC strengths. Users need time to recognize between the real and virtual image before understanding the exact ideas of the task. Fjeld, Juchli & Voegtli (2003) says "The mirror image presented to the user sometimes caused a perceptual problem. Some users

reported that they needed a time to become acquainted with mirrored image of both the interaction and the virtual environment."

As a conclusion, AR in Chemistry is very important for scientific study because it can give clearer explanation to students or users about the complex elements.

2.1.6 Virtual Reality (VR) in Chemistry

Briggs (1996) believes that, "In the future, students will be able to learn through studying in virtual worlds. Chemistry students will be able to conduct experiments without risking an accidental explosion in the lab."

For instance a work of Bryne (1996) called 'High School Chemistry Education and Virtual Reality'. The system allows users to form atoms and molecules from the basic building blocks of electrons, protons and neutrons. Participants also control the energy level and spin of electrons which determine where the electrons will go when they are released in the world and also help participants interpret the symbolism information of chemical (Bryne, 1996).

Besides that, VR in Chemistry could increase users' especially students' reflection towards emergency case that always occurs during lab session. It is because students have a lot of practice in virtual session that needs students to be aware of any emergencies during lab session. It has been proved by a research called Virtual chemistry lab teaches safety messages by Zayas (2004), found, "navigating through a virtual environment helps students to recall spatial information at a later date."

One of the disadvantages of VR in Chemistry is users could not be use or adapts the training in the VR environment into real situation. It is because sometimes users psychologically do not take the virtual training seriously because they have already set their mind to treat it just for the sake of fun. Mainzer (1999) says, "However, virtual reality in chemistry does not compete with the wet reality of chemical substances in nature. It is just a software tool of modelling, no more and no less."

However, VR in Chemistry also face some limitation. As Hansen & Stenholt (2004) say,

"Chemistry has proven to be a difficult field to computerize, but the solution presented covers the basic functionality needed in a complete system."

In a nutshell VR may encourage students to manipulate chemical element based on their interest to see the result. As a result, students' creativity and self-confidence would increase.

2.1.7 Augmented Reality (AR) in Mathematics Geometry

AR in Mathematics Geometry can attract students to study and to understand better mathematics because AR shown the geometry in graphic. This is because psychologically human could easily remember something that can be visualized rather than word in order to understand complex topic. As Hunt & Ellis (2004) mentions, imagery or visualization is directly mirror of the world. Furthermore according to Kaufmann & Schmalstieg (2003), the main advantage of using AR is that students could actually see three dimensional objects in 3D

space, complex spatial problems and spatial relationships so that they can be comprehended better and faster than with traditional methods.

AR in Mathematics Geometry could be also used in classroom. For instance a research by Kaufmann & Schmalstieg (2003) called Mathematics and Geometry Education with Collaborative Augmented Reality suggests that,

"With the aid of an additional computer with video camera and video projection screen, we can mimic this classroom procedure by projecting a live (monoscopic) video of the users (teacher/student) augmented with their current construction on a projection screen next to the users for the remainder of the class to watch. Figure 2.6 showed a teacher working in Construct3D with the mobile AR setup while a live monoscopic video of his current construction is projected onto a projection screen behind him."

Figure 2.6 : Mathematics and Geometry Education with Collaborative Augmented Reality [Kaufmann & Schmalstieg, 2003].

Besides that, AR in Mathematics Geometry can increase students' interest to learn Mathematics due to interactive module and the system could easily to be learned. For example, Kaufmann's (1999) research called "Construct3D - An Application and Framework for using Augmented Reality in Mathematics and Geometry Education. It is based on the mobile collaborative augmented reality system 'Studierstube'. The aim of this research is to improve spatial abilities and maximization of transfer of learning." Anecdotal evidence supports our claim that Construct3D is easy to learn, encourages experimentation with geometric constructions and improves spatial skills (Kaufmann, 2003).

Students working in Construct3D. (Viewing the construction from different side)

Students are working together in Construct3D. (Solving an example from vector analysis)

Figure 2.7 : Construct3D - An Application and Framework for Using Augmented Reality in Mathematics and Geometry Education [Kaufmann, 1999].

Furthermore, it can also increase social interaction between students and teachers because they could 'touch' the virtual objects together and share the information where teacher is able to control the situation. Kaufmann (2003) says, "One of the most important purposes of an educational environment is to promote social interaction among users located in the same physical space (Roussos et al., 1999). In collaborative Augmented Reality multiple users may access a shared space populated by virtual objects, while remaining grounded in the real world. This technique is particularly powerful for educational purposes when users are collocated and can use natural means of communication (speech, gestures etc.), but can also be mixed successfully with immersive VR or remote collaboration."

In addition, collaboration in these situations is largely determined by roles, and the teacher should be able to retain control over the activities (Kaufmann & Schmalstieg, 2003).

AR in Mathematics Geometry also has its limitations or weaknesses. Users might have difficulty to recognize and calculate the virtual objects due to confusion between the real and virtual objects. According to Kaufmann & Schmalstieg (2003),

"Hand-eye coordination is very difficult when spotting a point accurately in 3D space without haptic feedback or constraints. All students reported problems with the setting of points at given coordinates. As a consequence we implemented raster and grid functions."

As a conclusion, AR in Mathematics Geometry could give clearer vision of geometry problems. So that students can understand better and can attract students' interest.

2.1.8 Virtual Reality (VR) in Mathematics Geometry

By applying VR in Mathematics Geometry, we can make students 'see' the actual shape in order to understand better and to solve problem effectively with mathematical content interaction in new and interesting ways. According to Kaufmann & Schmalstieg (2000),

"The results of pilot study with geometry students actually using Construct3D are presented with an emphasis on suggested improvements and new techniques that can be applied within others virtual worlds."

Furthermore Kaufmann & Schmalstieg (2003) state that,

"About constructing in VR, students especially liked walking around and inside objects, the "playful" way of constructing and that spatial relationships and complex three dimensional situations are directly visible. The clearness of Construct3D's menu system and the audio help system were mentioned positively."

For example, Knudsen & Naeve (2001) project called "CyberMath which is suitable for exploring and teaching mathematics in situations where both the teacher and the students are co-present and physically separated. In this virtual reality environment the participants are represented by avatars. The space concept in virtual environments is different from that of any known physical space." Figure 2.8 showed CyberMath the generalized cylinders exhibit, where the distributed lecture was held.

Figure 2.8 : Presence Production in a Distributed Shared Virtual Environment for Exploring Mathematics. [Knudsen & Naeve, 2001].

Instead of advantages, VR in Mathematics Geometry also has some limitations or disadvantages. Technical aspects caused problems that reflect the participants' comments such as slow rendering speed, bad calibration of the whole system which resulted in small difficulties clicking menu buttons, inaccuracy of the pen due to position tracking inaccuracies and a small field of view caused by our HMDs. One person felt disoriented in the virtual world, another one experienced some form of cyber sickness, and another one said that constructing was strenuous. Concerning Construct3D and its user interface, people criticize that they had difficulties with choosing the right buttons on the pen. Further they suggested to implement a grid or snapping method, transformation of objects with constraints, intersections between primitives, and different colours for basic elements and to label elements. One user did not like the transparency we used for solids. (Kaufmann, 2000)

In a nutshell, VR in Mathematics Geometry may increase students' interest to learn Mathematics due to interactive module and they can 'feel' virtual objects.

2.1.9 Augmented Reality (AR) in Astronomy

If AR can widely be applied in astronomy, students can get benefit from it. According to Shelton & Hedley (2002), AR in Astronomy can help students to understand better complex concept or phenomena because students can control and manipulate virtual 3D objects.

One of the researches called Using Augmented Reality for Teaching Earth-Sun Relationships to Undergraduate Geography Students by Shelton & Hedley. Figure 2.9 showed a person perspective of earth-sun AR exercise.

Figure 2.9 : Using Augmented Reality for Teaching Earth-Sun Relationships to Undergraduate Geography Students [Shelton & Hedley, 2002].

Furthermore, AR in Astronomy could also give effective communication among students and teachers. For example Shelton (2002) observes that,

"astronomy-specifically the concepts involving seasonal variation of light and temperature or refer to as "earth-sun relationships." The virtual sun and earth are manipulated on a small hand-held platform that changes its orientation in coordination with the viewing perspective of the student. The student controls the

angle of viewing in order to understand how unseen elements work in conjunction with those that were previously seen."

Figure 2.10 shows the user interaction in learning astronomy.

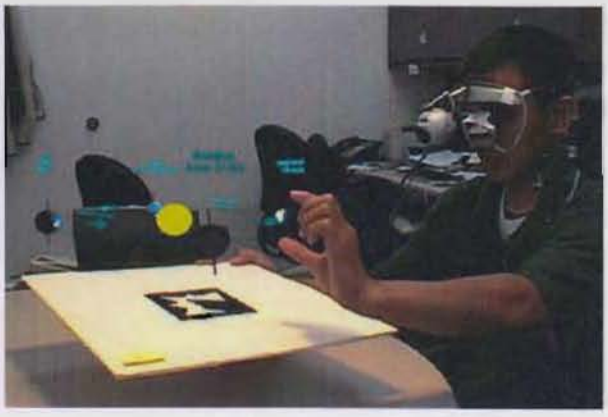

Figure 2.10 : Augmented Reality and Education: Current Projects and the Potential for Classroom Learning [Shelton, 2002].

As a conclusion, AR in Astronomy may help students to understand better about the universe by letting them to take control of the view.

2.1.10 Virtual Reality (VR) in Astronomy

According to Briggs (1996), "In the future, students will be able to learn through studying in virtual worlds. Astronomy students will be able to visit a range of virtual galaxies to study their properties." In addition, a study by *Physics World* (2002),

"The desire to make the best use of this expensively-obtained data has led astronomers and computer scientists to propose a new way to access and analyse

this data - a "virtual observatory" that will effectively recreate the observed universe within a network of computers."

When VR is applied in astronomy, students can understand better about universes by using standard data. This is because, the older approach acquire astronomers to observe on their own in order to collect data. This has been proved by *Physics World* (2002) who states that, "VR may provide data in the same format by make those data from many sources be handled in a single system at a range of wavelengths. It will help lift disciplinary boundaries."

Besides that, it may also encourage students to co-operate with others in order to achieve the goals. For instances a study by Bøegh (2000) found,

"The ASH project will build a Virtual Control Room that makes it possible for school classes to plan and carry out virtual missions to a comet to look for traces of life. The students will play the roles of scientists, engineers, mission control managers etc., and they will experience the excitement of making new discoveries in order to increase their interest to become engineers or scientists. Besides that, the Virtual Control Room will encourage co-operation between participants in order to give the experience of both the necessity and the strength of working together when exploring physical phenomena. Figure 2.11 shows View of the ASH Virtual Control Room."

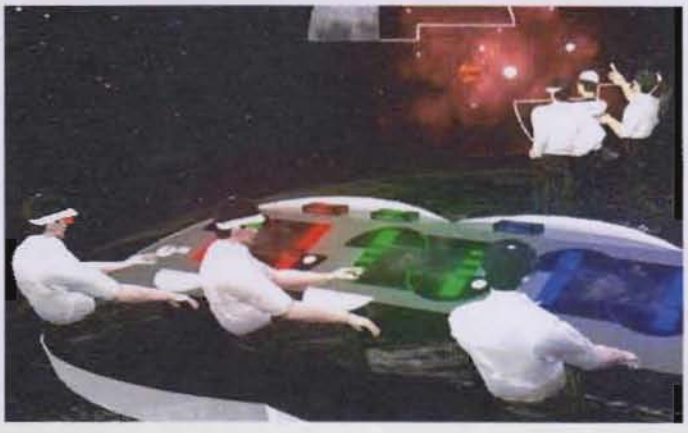

Figure 2.11 : The ASH project: A Virtual Control Room [Bøegh, 2000].

Instead of advantages, VR in Astronomy has also some limitations or weaknesses. The problem facing astronomy is that the amount of data is quite simply, astronomical meaning that the amount of observational data is roughly doubling every year (*Physics World,* 2002).

As a conclusion, VR in Astronomy may allow users or students to 'feel' the universe environment so that it can raise their understanding of complexity of universe.

2.1.11 Augmented Reality (AR) in Geography

Azuma et al. (1999) recommends that AR in Geography technique can be divided into two categories – prepared environment (indoor operation) and unprepared environment (outdoor operation). Furthermore, existing tracking techniques require *prepared* environments to ensure accurate results but few AR

systems operate in unprepared environments where the user cannot modify or control the real world (Azuma et al., 1999). However, Azuma (1999) believes that "Users operating outdoors, away from carefully prepared rooms, could use AR displays for improved situational awareness, navigation, targeting, and information selection and retrieval."

AR in Geography can help students to identify certain location accurately compared to the older approach of geography which uses drawing. As Azuma (1999) mentions, "AR application require accurate tracking to ensure accurate result." In addition, one of the key requirements for accomplishing this illusion is a tracking system that accurately measures the position and the orientation of the observer's location in space. Without accurate tracking, the virtual objects will not be drawn in the correct location and the correct time, ruining the illusion that they coexist with the real objects. (Azuma et al., 1999)

Beside that, students can also explore the environment to enhance their knowledge and to improve the understanding about types of soils, sea depth, etc. This is because; the user's view is augmented with location based information at the correct spatial location, thus providing an intuitive way of presenting such information about objects in their surrounding (Reitmayr & Schmalstieg, 2004).

Furthermore, students can explore and experience the situation like in the real environment so that they can adapt the situation into their life. A study by Reitmayr & Schmalstieg (2004) found "In AR the user's perception of the real world is enhanced by computer generated entities such as 3D objects and

spatialized audio. The interaction with these entities happens in real-time to provide convincing feedback to the user and give the impression of natural interaction. Augmented reality as a user interface becomes particularly powerful when the computer has access to location based information so that it can merge the virtual entities with real world objects in a believable manner."

For example of AR simulation city by Cara called Pompeii city which has been destroyed.

Figure 2.12 : How Augmented Reality Will Work [Bonsor, 2004].

Instead of advantages, AR in Geography also has some limitations or weakness. According to Reitmayr & Schmalstieg (2004), "The complexities of AR content resulted in limited demonstrators that only worked within a well defined environment. In order to scale the working environment to be comparable to a real environment, we also had to address the complex modelling and data handling needs of ubiquitous augmented reality applications."

Beside that, the problem of accurately aligning real and virtual objects which is known as the *registration* problem was also being issued but it can be

reduced by adding video tracking, forming our first inertial-optical hybrid. (Azuma et al., 1999)

In a nutshell, AR in Geography may increase students understanding and interest about the subjects.

2.1.12 Virtual Reality (VR) in Geography

VR in Geography could also help students to identify certain location accurately in 3D complex or less complex interaction map. It also allows users to wander freely in cyberspace even though they in the real world. As Ludwig (1996) observes that,

"VR is generally interpreted as artificial spaces that can be navigated in three dimensions and "feels" real. A geography student could visit the Gobi Desert, the Himalaya Mountains or perhaps the gulf coastal plains of Louisiana and "experience" the differences among environments." In addition, as Orton (2003) say that,

"Now a team of Carleton academics is creating the next-generation atlas. A virtual living atlas instantly available on the Internet will revolutionize the presentation of geographical information. Two Carleton projects – one depicting Antarctica, the other on Canada's trade relationships – will open windows into new worlds richly textured in layers of art, science, and technology."

For instance, Ludwig (1996) observes that "project called CENTRAL MISSOURI-Teaching Vertical Exaggeration showed the Missouri River bluffs which, on average are fifty to sixty feet high, look as though they could be major

peaks in the Rocky Mountains. It allows students to discuss the differences in each and evaluate where, when and how vertical exaggerations can be properly used. The instructor can actually "fly" the students (who are wearing 3D glasses) through the landscape turning left or right, gaining or losing elevation to analyze and discuss physical features, locations and the effect vertical exaggeration has upon the landscape." Figure 2.13 showed Central Missouri system for teaching vertical exaggeration.

Figure 2.13 : VIRTUAL REALITY: A New World for Geographic Exploration. [Ludwig, 1996].

Instead of advantages, VR in Geography also has some limitations or disadvantages. A research by Buckley, Gahegan & Clarke (2000) suggested that, in long-term visualization research challenges in geography analysis is called automated creation of information and information visualizations where it helps the user understand the underlying data that being presented. For example if the user states the problem, "Please show me the relationships between landscape conditions and in-stream habitats." and suddenly AR in Geography have an

aesthetically pleasing and effective graphic created based on domain knowledge and graphic design knowledge.

Besides that, according to Girardin (1995) "This multidimensionality makes it very difficult to determine the overall structure of the World-Wide Web. Since information about the orientation is globally poor, the so-called lost-in-cyberspace syndrome has become an important problem, limiting the cyberspace navigability."

As a conclusion, VR in Geography may allow students to see and 'flying' around the virtual environment in order to make them understand better about the topics that is being taught.

2.2 Conclusion

AR and VR researches should be studied more in order to make AR and VR application in most of educational branches of field succeeds. It is because AR and VR can give supplement to educational system to improve learning and teaching approach.

CHAPTER 3

RESEARCH METHODOLOGY

3.0 Introduction

This topic will discuss in details about research methodology of the study. It consists of systematic steps for having accurate value in order to enhance knowledge and information to others.

3.1 Research Methodology

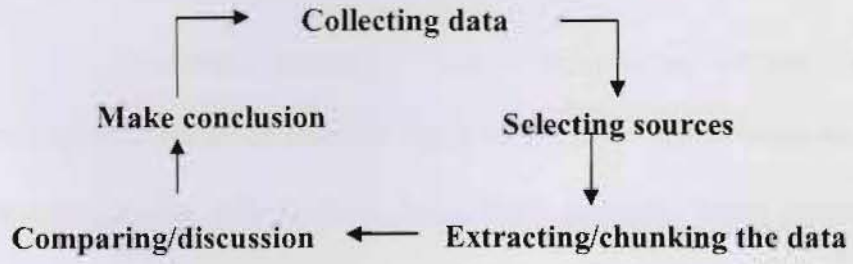

Figure 3.0 : Steps in research methodology

All information in this research is based on literature review by reading the relevant documents such as journals, articles, books and mostly from internet, in order to find out what has been written about the topic. This technique is called "case study" which gives freedom to comments and give relevant suggestions according to the past researches. Most of the resources are gathered from the internet and Unimas' library which is known as Centre of Academic and Information Services (CAIS). Based on Figure 3.0, the systematic steps of research methodology are :-

1. **Collecting data** - This is the process involved in collecting data that is related to the problem domain before selecting the relevant articles. The sources are collected from CAIS, and mostly from internet that consists of articles, journals and books. It is hard to find AR books in Malaysia; it could due to the subject still being in its infancy stage in Malaysia. Further more the study of AR in Education also require the study from the perspectives of education

psychology because of it relation with human psychology in order to increase students performance at schools.

2. **Selecting sources** – This is the process involved in selecting relevant articles, books or journals based on the topic that is being studied. After the articles, books and journals have been gathered, these sources will be examined by reading through all the relevant topics by using speed reading technique in order to have clearer idea on exactly what to study and to see whether it suits the main objectives or not. These relevant sources will be showed to the supervisor in order to get his advice whether the sources are appropriate. If it is accepted, the next level (extracting/chunking the knowledge) will take place. Otherwise, leave out the unwanted sources and try to find other sources.

3. **Extracting/chunking the data** – This process involved in extracting/chunking knowledge from the relevant sources. The main aim in this level is for taking the main ideas of the study by finding out other people's ideas that are related to this study problem in order to reveal methods of dealing with problem situations that may be similar to difficulties in this study. Then these ideas will be evaluated in terms of their relevance to research problem by comparing/discussion level.

4. **Comparing/discussion** - These ideas must be evaluated by making comparison or discussion with previous sources, supervisor or friends in order to have an accurate solution and to enhance knowledge about the research topic based on their suggestion. As a result, the new ideas will come out in order to improve previous research.

5. **Make conclusion** – Lastly, conclusion will be made after comparison and discussion have been made. This conclusion consists of the strengths and weaknesses when applying AR and VR in Education and the differences between AR and VR in education in terms of Chemistry, Mathematics Geometry, Astronomy and Geography. If the information is still not enough, then the steps of research methodology will be repeated until adequate information is obtained.

3.2 Conceptual Framework

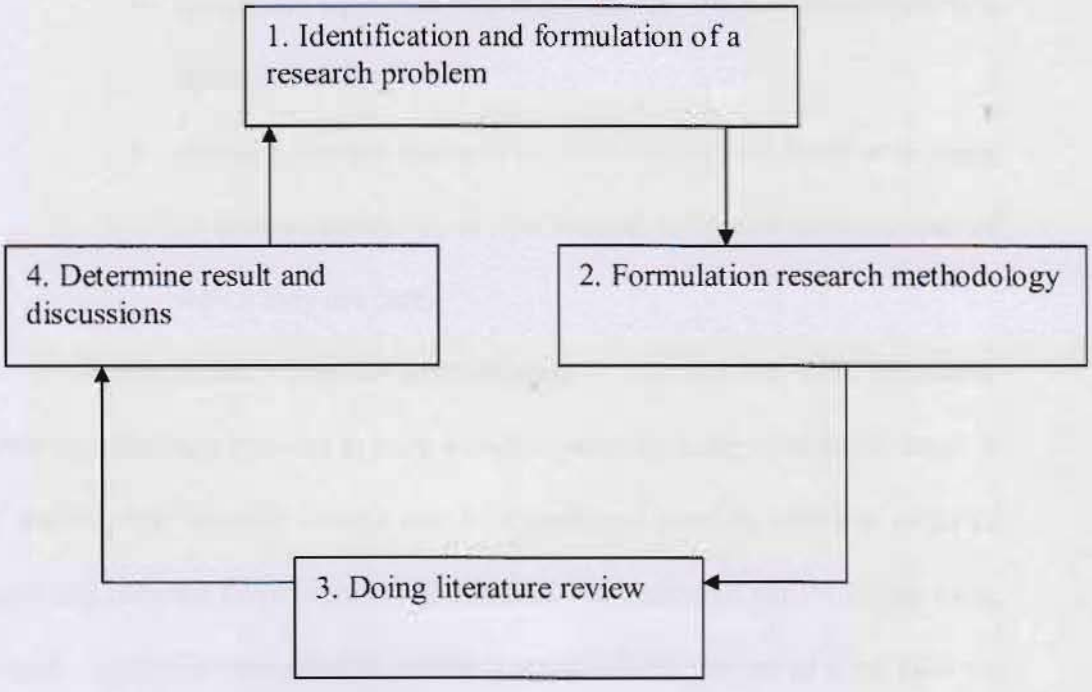

Figure 3.1 : Steps in research process.

Conceptual framework that be used is as shown in Figure 3.1. The steps in research process are:-

1. **Identification and formulation of a research problem** – This level is to identify any problem that is unsatisfactory or unsettling, any difficulty of any sort, a state of affairs that need to be changed, or anything that is not working as it should be. Research problems are frequently stated as research questions which lead one to have clearer ideas as the focus of study. This research will start with questions that would to be answered. The essential characteristics for good questions are:-

   - feasible (can be studied with available resources)
   - clear (key words in the question that lead to specifically or precisely what want to study)
   - significant (question that might ask in order to understand this study in details)
   - ethical (question that will not involve physical harm or damage to human beings or to the natural or social environment of which they are part).

2. **Formulation research methodology** – this process is to formulate research methodology in order to have accurate value by using systematic steps. It is for making this research's result can be trusted and used by others in order to improve and enhance knowledge or information. This research can do in two main strategies – qualitative research (to obtain a more holistic picture of what goes on particular situation or setting) and quantitative research (involve the collection of

numerical data in order to explain, predict, and / or control phenomena of interest).

3. **Doing literature review** – This step is to dig into the literature to find out what has been written about that topic by reading what others have done or written. This process is known as a literature review. The opinion of experts in the field will help to know and understand better in detail about the topic. It helps to find out or locate other people's ideas that are related to the research problem.

4. **Determine result and discussions** – This step is to tie together the main threads revealed in the literature reviewed and it presents a composite picture of what is known or thought to date. Findings of others can be tabulated to give some idea of how many other researchers have reported identical finding.

3.2.1 Research Framework

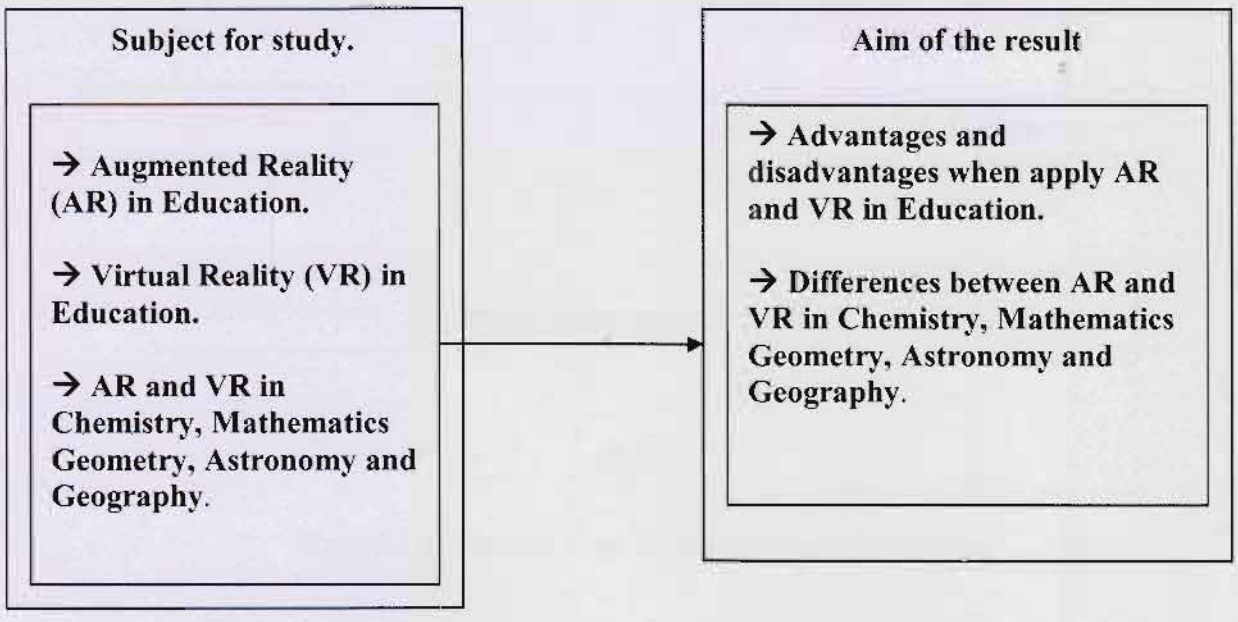

Figure 3.2 : Research framework.

Referring to Figure 3.2, the subject for this study are AR and VR in Chemistry, Mathematics Geometry, Astronomy and Geography, Virtual Reality (VR) in Education and Augmented Reality (AR) in Education. This information will lead to have the accurate results. The aim of the study's results are advantages and disadvantages when applied AR and VR in Education and differences between AR and VR in Chemistry, Mathematics Geometry, Astronomy and Geography.

3.3 Overall research flow

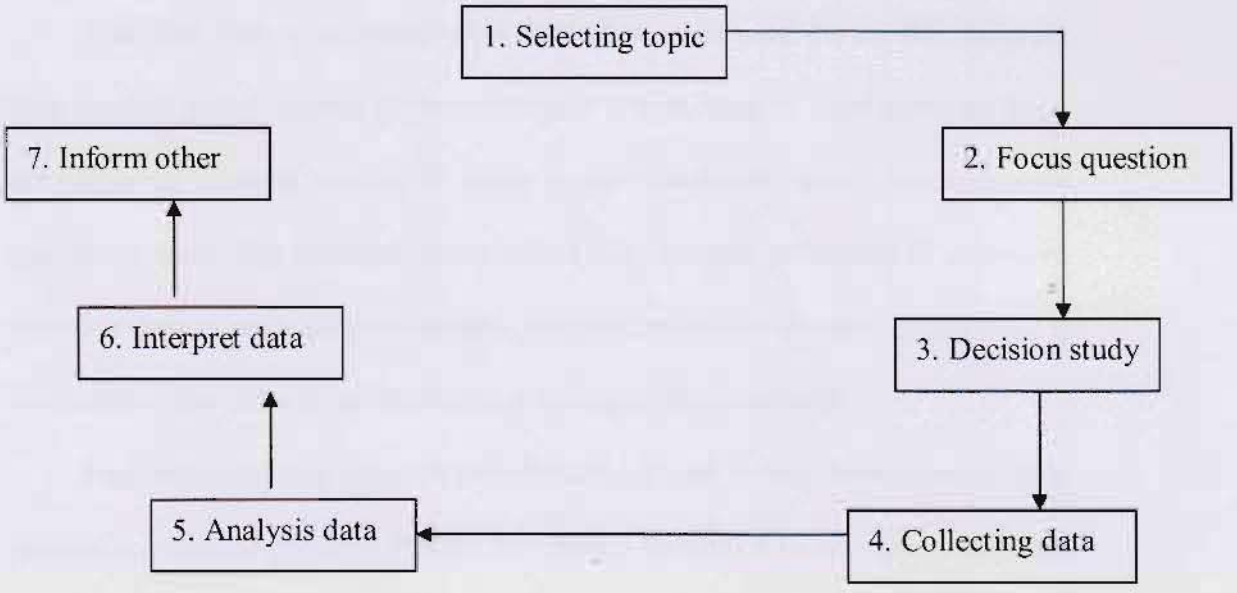

Figure 3.3 : Overall steps in research

Referring to Figure 3.3, the first step involved in the research process steps is selecting topic that would be studied based on interest. It is important to

determine the topic of study in order to form strategies that are going to be used during the research. Furthermore, this research that is going to be studied until sure results are obtained. The successful research is when it can achieve the goals and knows what problems to look for.

The questions that would be studied are focuses based on the researchers' own experience and previous studies in order to come up with justifying new problems to be solves. The problems will be easier to solve by narrowing down the scope in order to have a well-defined focus of the study. This strategy will be more effective when the question's characteristics, such as feasibility, clearness, significance and ethics are being considered.

The third step is to decide what method is to be used during the research. This process is also known as decision study which leads to more constant steps for gathering relevant sources in order to have accurate value. This step uses qualitative study and is called case study which involves collection of extensive narrative data in order to gain insights into phenomena of interest. In addition, it re-examines and reflects on the data and concepts simultaneously.

Fourth is collecting relevant data from CAIS and mostly from internet. This process is based on previous studies by reading through it to get clearer ideas on the topic. The sources consist of books, articles and journals. Besides that, it can also reveal methods of dealing with problem situations that may be similar to current study difficulties.

Fifth is the analysis of data by extracting and comparing the knowledge. It is essential to get similar cases or studies to compare with current problems. It will

be more effective and faster by looking through all the sources using speed reading technique.

Then it will lead to interpretation of data so that be new ideas or suggestions could be obtained by comparing and discussing about the result with advice or suggestion from supervisor and friends. This process will give the result of the research, such as the advantages and disadvantages when applied into AR and VR in Education.

Lastly, is to inform the other by justifying the study based on the state of knowledge revealed in the past literature. It will help to enhance knowledge and information about the study more accurately. This process has been done by using the literature suggestion about appropriate courses of action to try to solve the problems.

3.4 Conclusion

This topic may convince others that this study's results are accurate based on the systematic steps that have been used. The steps are for gathering information in an appropriate manner which is based on research methodology. These steps are based on the basic conceptual research framework. Overall this study method consists of seven steps that have been explained in overall research flow.

CHAPTER 4

FINDINGS AND DISCUSSIONS

4.0 Introduction

This project will discuss the study's result based on comparing with previous sources or discussing with supervisor and friends in order to have the accurate solutions and to enhance knowledge about the research project based on suggestions.

4.1 Advantages and Disadvantages When Applying AR in Education

Based on findings, AR in Education can be divided into two categories – AR in schools and AR in Technical Training but there is no AR for Special Education and AR in Distance Education yet. It is due to limitations of the system and equipments. In other word, AR still could not interact at the same time with the

users who are in difference places. For instance a study by Kaufmann & Schmalstieg (2003) called Mathematics and Geometry Education with Collaborative Augmented Reality found AR architecture that could be used for classroom where the setup just used for users in the same place at the same time. It is because a teacher's work is projected onto a projection screen behind him by a live monoscopic video.

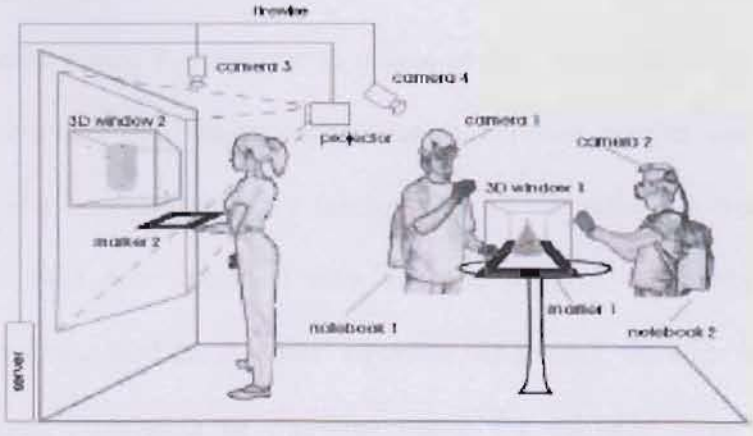

Figure 4.0 : Mathematics and Geometry Education with Collaborative Augmented Reality [Kaufmann & Schmalstieg , 2003].

However, a system for AR Distance Education to be used in future has been developed. For example a research by Cooperstock (2001) called The Classroom of the Future: Enhancing Education through Augmented Reality suggested eClass lecture capture that could be viewed through a web browser and RealPlayer anytime after class. Figure 4.1 showed a sample of that system.

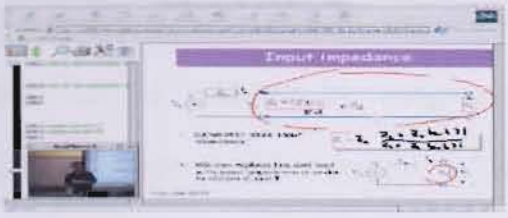

Figure 4.1 : The Classroom of the Future: Enhancing Education through Augmented Reality [Cooperstock, 2001]

Besides that based on my observation, AR in Education can produce better education for society due to better interaction between teacher and students that has been increase where it is similar to a face-to-face communication. In other word, AR encourages two ways communication between teacher and students compared to older approach where a teacher does all the talks and students just seat and hear. This new approach may increase students' creativity because teachers do not spoon-feed the students' anymore. As a result, students freely give their suggestions, comments or opinions about the subjects based on their understanding and they still have opportunity to review the lesson even after class through web browser.

As Billinghurst (2003) says,

"the advantages when using AR in Education is in an Augmented Reality interface where students can be seated around a table and see each other at the same time as a virtual heart floating in their midst. This results in conversational behaviour that is more similar to natural face-to-face collaboration than to screen based collaboration [Kiyokawa 2002]."

Furthermore, AR could also provide valuable information to students and encourage them to learn something by doing it in safe environment; so that users'

can enhance understanding of subject's content especially for complicated information. This method can be achieved by using combination of real environment and virtual scene in order to attract students to feels positive toward education. It is because AR allows users to "keep control"; to see the real world around them and to give the users the freedom of sight needed to move around (Kaufmann, 2003). In addition, according to Adams (2005),

"Humans learn best by doing, not by reading or listening to lectures. The more senses are involved (sound, sight, touch, emotions, etc.), the more powerful the learning experience. That's why today's best teachers are those pioneering individuals who take the effort to engage their students in meaningful activities that reach students at multiple levels."

Instead of advantages, AR in Education also has some limitations or weaknesses. The main limitation of AR is AR environment is difficult to be used for outdoor activities due to difficulty to measure the position accurately and the orientation of the observer's location in space. In Held's (2003) view, "Potential applications of AR are within environments that do not provide ideal lab condition (e.g. outdoor, factories) or demand extremely high accuracy (e.g. medical)." However, if AR designers build a system that can be use for a certain place in the future, that may supply numerous approach in educational system.

In addition, AR in Education also had very high potential of addiction to students because it has high potential to take control of the users' mind in terms of mental manipulation, such as a system that can instill hate among nation that may lead to misunderstanding and war. However if they used it in correct ways, it will turn to be an amazing information system where users can adapt what they already

learn in AR environment to the real life.

As a conclusion, AR in Education should be implemented as a supplement to older education system in order to produce creative students who can adapt what they already learn in school to real life.

4.2 Differences between AR and VR

As is explained before, AR and VR is almost the same in terms of interaction among users in attractive ways by using the graphics virtual objects, creating a safe environment and providing valuable information to user. Based on findings the differences between AR and VR can be divided into four categories. There are :-

i) **Interaction** – VR allows users fully interact within the virtual scene where they can 'feel' and 'fly' in the environment as if they being in that situation. On the other hand, AR allows users to interact within combination of the real and virtual environment.

ii) **Scene** – The VR system involve with Virtual Environment (VE) only where it completely replace the real environment. However, the AR system involve with combination of real and virtual scene. Furthermore, AR designers will try their best to put in as much as possible the real environment.

iii) **Equipment** – The minimum equipment for VR is computer and the VR system. On the other hand AR needs computer, computer camera (webcam) and the AR system.

iv) **Technique** – The VR system is less complex compared to AR in terms of the technique that is being used because VR involves only with the 3D virtual environment. But AR involves with a lot of calculation in order to detect object, motion, etc.

These differences will be seeing clearer in Table 4.0.

Category	Virtual Reality (VR)	Augmented Reality (AR)
Interaction	User fully interact within the virtual scene	User interact within combination of real and virtual scene
Scene	Involve Virtual Environment (VE) only where completely replace real environment	Involve combination of real environment and virtual scene
Equipment	The minimum equipment is computer and the VR system	The minimum equipment is computer, computer camera and the AR system
Technique	The system is less complex compared to AR in term of the technique that been used	The system is more complex than VR in term of the technique that been used

Table 4.0 : Differences between AR and VR

4.2.1 Case Study 1 (AR and VR in Chemistry)

There is not much difference between VR in Chemistry and AR in Chemistry. Both systems encourage students to create their own formulae and manipulate the virtual objects freely in a safe environment without feeling afraid of dangerous consequences by their actions. It is because AR and VR involve only computers. As a result, teachers could create the hobby of question ask up among students and encourage students to search for answers to whatever curiosity they have about the subjects without depending too much on teachers. On the other hand, the older approach in studying chemistry expose students to dangerous environment due to dangerous chemical. But they still give same result even though both are using different ways of teaching.

Findings shows that, the main difference between AR and VR in Chemistry is AR in Chemistry is still not developing for complex experiment compared to VR in Chemistry. As we all know, chemistry involves several of chemical liquid that could either cause danger or not. The mixture of these liquid will produce new chemical substance and this process may involve changes of liquid appearance, colour or smell. It is difficult to determine the colour changes in AR due to the intensity of the objects and the position of the light source. Different results are given for the same colour if the position of the light source is not permanent. Raskar, Welch, & Wei-Chao Chen (1999) says,

"One of the important tasks in achieving compelling augmented reality is to create association between the physical objects and the graphics primitives that

will enhance those objects when projected. Examples of graphics primitive are lines, text, texture mapped polygons or even complete 3D (virtual) objects."

On the other hand, VR in Chemistry can develop a system that can be manipulated or be a dangerous experiment in virtual scene. This is because designers do not have to think about the consequences that might caused by the dangerous substances. According to Raskar, Welch, & Wei-Chao Chen (1999), "pure VR has the advantage in that you can show the user "anything," static or dynamic, without the need for a physical model."

As a conclusion, AR and VR in Chemistry should be implemented as a supplement to educational system in order for students to understand better about the complex chemical processes involved and to decrease negative thought about science subjects.

4.2.2 Case Study 2 (AR and VR in Mathematics Geometry)

AR in Mathematics Geometry uses graphical aspects for creating a virtual geometry forms in order to attract students to be involved in the calculation and discussion activities among themselves and teacher as well as to increase understanding about this subject. On the other hand, VR in Mathematics Geometry could create the whole virtual mathematics environment so that each student can 'see' the actual shape in order to understand better and to solve problem effectively with mathematical content interaction in new and interesting ways. In other words VR allow users to play around or 'fly' in the VR mathematics scene only - without interacting with other users in the same scene.

Based on findings, the most interesting in AR and VR system is it allows students to move around in order to make these students 'feel' like in the actual scene. Kaufmann (2003) points out that "the AR system give users the freedom of sight needed to move around."

Besides that, users who used AR in Mathematics Geometry also have some limitations in terms of difficulty and it is time consuming to calculate the virtual objects due to confusion between real and virtual world. It is due to limitation of human where they need some time to adapt the new technology or challenge into their life. Based on findings, it could be solved by teach each students slowly from early educational system – kindergarten or primary school. On the other hand, VR in Mathematics Geometry which is familiar with the computer games enable users to easily interact and control the system. It is because nowadays users' are familiar with the computer games so they do not have much difficulty to control the virtual environment.

As a conclusion, both system – AR and VR in Mathematics Geometry is similar in terms of using colourful graphic models of geometry for attracting students to learn mathematics in a happy and fun approach. Furthermore the main objective to increase students' enthusiasm in Mathematics would be successful if everyone gives co-operation and support to this system.

4.2.3 Case Study 3 (AR and VR in Astronomy)

VR in Astronomy has proven that VR system could allows users to communicate and co-operate with other users in order to help students to understand complex environment, same as the functions that be applied in AR in Astronomy. The main objective to develop VR in Astronomy is to increase students' interest to become scientist or engineers where students can 'feel' as they are in the real universe and can control the scene in order to achieve the goals. On the other hand, AR in Astronomy is more interesting in order to increase interaction and communication between students and teacher and to instil, students love towards astronomy subject.

The findings show that, there are few sources of AR and VR in Astronomy because it is difficult to build the system accurately due to limited data available in the scientific study of universe. Gervautz (1999) claims that, "researchers have to apply different techniques to observe in order to estimate the age of universe." However there are more VR system that be applied in astronomy than AR approach. It is because VR creates only the whole virtual objects without worrying about the physical objects. Even though there is much VR system in Astronomy compared to AR, but it still has some limitations in terms of details available in astronomy data. As a result, students still can play around with the basic astronomy concepts in order to expose students to that subject.

As a conclusion, AR and VR should be implemented in every country especially in Malaysia to attract students to understand better about the subjects and universe. Besides that, we can decrease negative perception about sciences subjects among students.

4.2.4 Case Study 4 (AR and VR in Geography)

The similarity of both AR and VR in Geography system is that it can teach students about universe coordination, places landscape, cities visualization, etc. Based on findings, mostly AR in Geography is applied for tourism (tourist guide), history, etc. On the other hand, VR in Geography can be applied in various concepts such as past and future landscape of cities or places.

Besides that, the main difference between AR and VR in Geography is AR could be used either for outdoor or indoor activities but VR could only be used for indoor activities only. This is due to the differences equipments that are being used and the functions of each system. As Shelton (2002) says, "AR allows a person to view one or more virtual 3D objects in the real-world environment." However AR in Geography faces some problems to develop the outdoor system where they need to use it in the permanent places only in order to have accurate information. But users will not face the same problem if they used VR system.

The most advantages of implementing AR and VR in Geography in education system is that it can help students to identify certain location accurately compared to the older approach of geography which uses drawing. Furthermore, these systems allow users to control the environment for having better understanding about the complex concepts.

As a conclusion, AR and VR in Geometry can be implemented as a supplement in geography subjects in order to increase students understanding and give accurate information. As a result, students can adapt it into their real life in

order to decrease difficulty in real environment especially when their work in the future is related to geography.

4.3 Discussion on AR and VR in Education

Based on findings, AR in Education is the best compared to VR in Education even though both have its own strengths and limitations. It is because AR in Education can encourage students to have face-to-face communication between teachers and among them in a fun and attractive approach where students can freely control the environment without needing the teachers to spoon-feed them anymore. Kaufmann (2003) expresses the view that "AR allows users to "keep control", to see the real world around them and to give the users the freedom of sight needed to move around." Therefore, students can enhance their creative knowledge without misinterpretation. This will make students encourage students for having positive competition because they do have friends to compete and share with. It is because psychologically, human being cannot avoid from society. Furthermore, the educational system is part of society and these relationships have strong effect on what schooling can achieve (Long, 2000). As a result, it may increase student's creativity and productivity.

Besides that, AR in Education also should be implemented to Malaysia context as a supplement to recent education system. This dream will come true if the AR system can be exposing to students from young age, such as kindergarten. In order words, based on the early exposition, the AR in Education information

will be spreading out from a person to the others.

Furthermore, AR in Education will come true if each Malaysian school slowly adapt AR and VR in the learning of subjects. A study by Liarokapis, Petridis, Lister & White (2003) found, each school could use computer, video camera and Head Mounted Display (HMD) for building AR environment in order to keep total budget low with ergonomic and reusable AR system. The example of the system is shown as Figure 4.2.

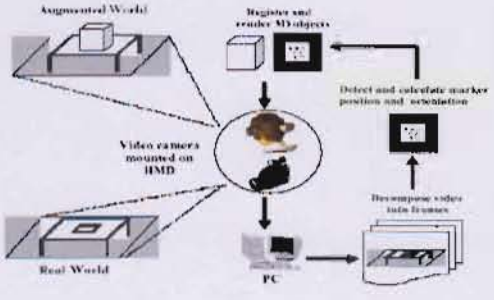

Figure 4.2 : Multimedia augmented reality interface for e-learning (MARIE) [Liarokapis, Petridis, Lister, &White, 2003].

In a nutshell, AR in Education can give supplement to educational system in terms of increasing learning approach. So that, students are more motivated to come to schools and can adapt what they already learnt or knew to new challenges they confront later, especially when they go to work.

4.4 Conclusion

This project may give ideas to other researchers about any problems that AR and VR designers have to confront. Besides that, others may come out with other solutions or suggestions that may help future development. As we all know, everything in this life has strengths and limitations but if we can use it in positive ways, it will give us many benefits. As a result, hopefully this system could produce societies that love to learn and adapt it to their real life in order to create more intelligent person.

CHAPTER 5

CONCLUSION

5.0 Introduction

This final topic will justify the study based on the state of knowledge revealed in the literature. This process has been done by using the literature suggestion about appropriate courses of action to try to solve the problems.

5.1 The Summary of Findings

From the previous chapter we can summarize the differences between those applications as follow.

- In case study 1, the result showed that AR and VR in Chemistry has similarity in terms of it can create a safe environment and provide valuable information to users especially students because they can explore and increase better understanding about the complex

explanation compared to older approach where students are more exposed to dangerous environment due to dangerous chemical. As a result, society especially students may decrease their negative thought about science. The main difference between AR and VR Chemistry is AR system just give basic exposures. However VR in Chemistry involves more dangerous experiment where students can freely manipulate the virtual scene in order to expose students to complex cases or experiments.

- In case study 2, the result indirectly showed that AR and VR in Mathematics Geometry might increase students' interest to learn Mathematics due to virtual graphics objects and they (users) can freely move around in order to manipulate the virtual environment. However each system has some limitation where AR users' need time to adapt and to calculate virtual geometry objects in learning AR because of confusion between real and virtual scene, compared to VR approach. It is because nowadays society is more familiar with games which are part of VR system compared to AR technology which is still new in society understanding.
- In case study 3, the result showed that VR in Astronomy has proven that VR system can also allows users to communicate and give cooperation with other users in order to help students understand complex environment in order to achieve their mission or goal. Besides that VR in Astronomy aims to increase students' interest to become scientist or engineers. On the other hand, AR in Astronomy

focused more to increase communication between students and teacher in order to attract students to love and understand the astronomy subject. The similarity between these systems is about the limitations of sources due to limited data especially it is about the scientific study of universe. However more VR system would be applied in astronomy than AR approach. It is because VR just create only the whole virtual objects without worrying about the physical objects. Even though VR give only basic explanation in astronomy but it already gives much information to users in order to explain what astronomy is all about.

- In case study 4, the result showed that AR in Geography has been developed for outdoor and indoor activities in order to increase users' understanding in the real world application. However this outdoor system still has problem to give accurate information due to changes that always happen in real environment. But AR designers would develop a system that could be used for permanent places without bothering about the colour of the building. On the other hand, VR system could be applied for indoor activities only. It is because of the difference equipments and functions between these two approaches. The similarity between AR and VR in Astronomy is that is it could help students to identify certain location accurately compared to the older approach. It is because these systems allow users to control the environment for having better understanding about the complex concepts.

5.2 Contribution

Contributions of this study are:-

i) Contribute more information for AR in Education for Malaysian context.

ii) Give suggestion to implement AR in Education for developing country especially Malaysia.

5.3 Recommendation For Related System Designer

This study benefits the others researchers, AR and VR developers by helping them to identify the weaknesses and strengths each application in order to make its application to become reality in future. Below are some suggestions for the researchers, AR and VR developers :

i) AR issues such as application for outdoor and indoor activities should be give attention in order to make various in AR technology in order to increase users' interests.

ii) VR issues such as the equipments that can make users easily tired after few hours using it in order to make the approach become successful in the future.

5.4 Recommendation For The Future Study

For further research, it is strongly recommended that more studies on various aspects of education subjects be conducted in order to establish a more complete framework for useful reference in the future AR and VR development. Meanwhile, it also recommends reviewing more problems and solutions in order to justify which aspects are more important and should be added to the current system.

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