2010 Second International Conference on Computer Engineering and Applications

Preliminary Evaluation on User Acceptance of the Augmented Reality use for Education

Desi Dwistratanti Sumadio
Computer and Information System Department
Universiti Teknologi PETRONAS
Bandar Seri Iskandar 31750 Tronoh Perak, Malaysia
dek.desi@gmail.com

Dayang Rohaya Awang Rambli
Computer and Information System Department
Universiti Teknologi PETRONAS
Bandar Seri Iskandar 31750 Tronoh Perak, Malaysia
roharam@petronas.com.my

***Abstract*— Augmented reality is a technology that enables user to interact with 3D virtual object and real world in real time application. The use of Augmented Reality (AR) in education shows a potential to enhance traditional learning method. The purpose of this study is to observe the familiarity of AR application especially its implementation in learning environment, and to determine the usefulness of AR application in education. The study was conducted during Malaysia Technology Expo 2009 in small scale participants consists of students, teachers, and industrial people. The result showed that most of the participants never been experienced with AR application before, but the idea to implement AR for education are well accepted with a very positive feedback. Based on the findings, some issues and user expectation for further development of AR application in learning environment are being discussed.**

Keywords- Augmented Reality in Education, Usability, User acceptance

I. INTRODUCTION

The use of technology in education enable learning process to be more active, attractive, motivating, simulating, and meaningful to the student [9]. Changing of educational system will move away the memory based learning to more motivated and creative education [2]. The traditional learning method should be improved to make the education quality better [2]. An Augmented reality as an advance technology that enable user to interact with virtual and real world in real time application [1] can bring more natural experience, raises attention and motivation to students with a high potential to enhance the learning experience [6, 17]. AR also can enhance the effectiveness and attractiveness of teaching and learning for students in a real life [7, 13, 14]. Even though Augmented Reality technology is not new, its potential in education is just beginning to be discovered [12]. In addition, to make this works, educators should work with researchers in the field to explore how these characteristics can best be applied in a school environment [11].

AR technology needs a lot of study and research to develop a good visualization based on the user needs and user expectation to avoid the usability problem [5, 16]. The usability testing for AR technology aims to find and repair some of the usability troubles since the earlier stage of the development because the earlier the problems are predictable, the less expensive and less time development effort to fix the application [18].

An AR prototype in this study was developed based on Malaysia curriculum on physic subject for secondary school. The prototype is provided for the user to experience and learn about heat absorption and radiation experiment. The scenario of the content was based on the physic book for secondary school [3].

The first testing of the prototype has been performed during the MTE 2009 in Kuala Lumpur, Malaysia. The participants were the people in the exhibition, consists of some teachers, students, and industry people. The objectives of the evaluation were to observe the familiarity of AR application especially its implementation in learning environment, and to determine the usefulness of AR application in education. Several evaluation techniques were used; observation, usability questionnaire, interview, and think-aloud protocols.

This paper presents the first usability evaluation of the AR prototype from the MTE 2009. The results are based on the usability questionnaires filled by the participants as the quantitative result, the observation and other evaluation techniques will be summarized as the qualitative result of the evaluation. The rest of the paper is prepared as follows. Some of the related work in the area are presented in the next session. The evaluation setup and approach (the AR prototype, study design, and method is briefly explained in section III. The results and discussions are presented in section IV. The papers ends with conclusion in section V.

II. RELATED WORKS

Even though the growth of Augmented Reality technology has been studied for more than forty years, but the focus of the formal evaluation on AR application has only recently developed [7]. Bach and Scapin [19] established that there is no usability evaluation methods purposely designed for Augmented Reality system. Other evaluation method in other field research can be adopted to evaluate AR system [15, 19]. Some evaluation methods that

978-0-7695-3982-9/10 $26.00 © 2010 IEEE
DOI 10.1109/ICCEA.2010.239

can be used in AR evaluating system are questionnaires and interviews, inspection methods, and user testing [19]. Questionnaires and interviews are valuable for collecting subjective data, user preferences, and to evaluate the performance data, and user testing has been the major method in other disciplines [15, 19].

Duenser et al. [7] pointed that the reason for the lack of user evaluation in AR could be a lack of education on how to evaluate AR experience, how to appropriately design experiments, choose the appropriate methods, apply empirical methods, and analyze the results.

The evaluation method used in this study was based on the user-based experiment that is adapted from the evaluation method of Construct3D [10] that used ISONORM [4] usability questionnaire to the needs of the evaluation. As Gabbard and Swan [18] said that user-based experiments are vital for motivating design activities, usability, and discovery the early stage usability problem of an emerging technology such as Augmented Reality.

III. STUDY SETUP AND APPROACH

A. The AR Prototype

The AR prototype used in this study is the enhancement of the previous "Portable Augmented Reality Science Laboratory" project [8]. The prototype was enhanced by creating new 3D models and being improved with some animations. The content was adapted from the Malaysia junior high school curriculum for physic subject [3]. The AR prototype showed an experiment of heat absorption and radiation. Students learn the concept of how dark material absorbs heat better than white material.

AR prototype used in this study does not need user to use head-mounted display. It is only require a desktop computer and webcam. The webcam was placed in front of the board in certain position, and some markers were provided to play with the system.

B. Study Design and Method

The study was conducted with qualitative and quantitative research design. As the qualitative research design, think-aloud protocols, interviews, and observation during the experiments were recorded to discover participant's thoughts, how their interact with the application and their respond related of the use of AR for education purpose. A questionnaire also provided to measure the AR system design. The questions used were adapted from ISONORM usability questionnaire by Prumper [4] to the needs of the evaluation. The whole process was videotaped and audiotaped.

First, participants were given some explanations about how augmented reality works. Then they were introduced to the AR prototype. The instructions to use the AR prototype were given on the provided board. Some markers have been set based on the step given. They need to put the marker in the proper positions on the board. User changed the marker based on the step provided.

There are four steps in this experiment user should follow. The first step, user will be introduced with the apparatus needed for the experiment. They put the markers from the step one and some 3D models of the apparatus (black beaker, white beaker, thermometer and Bunsen burner) will be displayed in the monitor screen. User can play with the marker and rotate the marker to see the model in different angel. Second step, user will be showed the setup of the apparatus. Users change the markers and put the markers from the second step on the board. The display of the 3D model in the seconds step shows how to setup the apparatus for the experiment. The thermometer is put inside each beaker (white and black beaker) and the Bunsen burner is placed in between of the beaker. In the third step, assumed that the Bunsen burner was placed within ten minutes, and then the animation of the increasing temperature in the thermometer is displayed. The temperature animation in the black beaker increased faster and higher than the heat in the white beaker. This animation was adapted from the real experiment. On the last step, some questions are provided to test the understanding of the experiment conducted.

IV. RESULT AND DISCUSSION

In this section, the result from the study will be explained and the further details about the findings will be discussed.

A. Participants

The total of 33 respondents from which 20 females and 13 males; 5 students were from the high school, 4 students from the diploma level, 15 students from undergraduate level, 2 students from postgraduate level, 2 high school teachers, and 2 people from the industry.

From the profile of the participants above, the knowledge and the usage of the computer in daily life is reported as 22 participants always use computer in daily life, 3 participants often use computer in daily life and 8 participants seldom use computer in daily life.

B. Participants Familiarity of AR application in learning environment

Most of the participants said that this was their first time experience with AR application. 27 out of 33 participants never see AR application before. During the observation, the participants were asked what they know about AR.

TABLE I. AR EXPERIENCE

Level of AR Experience				
Never	Rarely	Seldom	Always	Not Sure
27	2	3	1	1

Most of the participants did not know what AR is before they were given some explanation and experienced with the AR prototype.

Teacher: "... I never know this application before. I am impressed. It will be a very good method for learning"

Student: "This is my first time experience with this kind of application. It's cool!"

Moreover, after the demo they understood what AR is and how it works. Only a few of them knew about AR and gave some examples like virtual keyboard and online webcam function that has face detection and can overlay face with some images on top of the face.

Industry people: "... Yes, somehow, I ever saw this kind of application before, but I cannot remember, oh maybe like virtual keyboard. It is very impressive..."

The table I shown above summarized the level of AR experience in this testing. The result indicates that people not familiar yet with AR application especially its implementation in education but even in the very first time of experience, the participants give a very good feedback in term of the AR use for education.

During the observation, the participants also asked if they have learnt something about AR after the demo.

TABLE II. UNDERSTAND AR AFTER THE DEMO

Understand AR after the Demo		
Totally Agree	Partially Agree	Not Sure
25	7	1

The participants reported that they gained something new and understood how AR works after the demo and its advantages if it is applied in daily learning activity. However, some of them said that the time of the observation and the scenario provided in this demo is not enough. It shows that people are interested to know more and to experience with AR technology more. Moreover, the details of the usefulness perception of AR application will be discussed in the next session.

C. *Usefulness Perception of AR application in learning environment*

From overall survey, 27 out of 33 respondents totally agree that the use of AR application in education will be very useful, 5 partially agree to use of AR application in education, and only 1 respondents not sure about the use of AR application in education. The number indicates that the acceptance of AR use in education is well accepted. Below is described some comments regarding participants thoughts about the importance of AR application implementation for education.

TABLE III. USEFULNESS OF AR USE IN LEARNING

Usefulness of AR in Learning		
Totally Agree	Partially Agree	Not Sure
27	5	1

Teacher: "Fantastic, it will be a very good method for learning process. This application is easy to use and student will enjoy learning with this kind of application because this technology can help student to visualize, imagine and understand the concept of the experiment before they do the real experiment, so the learning process will be faster..."

Teacher: "Student will enjoy learning with this application but still the possible real hands-on experiment should be done..."

Student: "I enjoy learning with this application, it will be no more sleeping in class"

Student: "It's an excellent project. I like it because it's kind of new method and it makes learning a whole lot more fun and I easier to understand the experiment"

The respondents also expect the further development of the prototype would be improved with the simulation of safety issues and how student should handle the apparatus for the experiment.

Teacher: "Having this application will make the learning process easier, and it will be very excited if the application can come out with the simulation safety precaution and handling apparatus technique..."

In term of the 3D virtual objects displayed and the interaction with the AR application, they feel it will be good to have more real look like 3D models and to have more interactive choice. Participants expected to have this AR application not only in one experiment, but also in many other subject.

Industry people: "It's a very unique method for learning, and it will be very useful, but I expect the display of 3D models be more real look like, and the application will be a lot more fun if we can do more interaction with the application..."

Student: "It is a very interesting application, yet it will be better if the application is provided to vary experiments not only one subject."

1) *Measurement of AR prototype design*

Participants were asked to answer some general questions related to the AR system design in term of the efficiency of the system, the helpfulness of the system to solve task, user control, and the suitability for learning. All

the dimensions were measure on a five point scale (where 1=worst to 5=best). The questions were adapted from the ISONORM usability questionnaire by Prumper [4] to the needs of the evaluation. The summary of the result are shown in the table IV.

TABLE IV. MEASUREMENT OF AR SYSTEM DESIGN

Item	Mean	Standard Deviation
Suitability to task (efficiency of the application)		
Easy to use	4.697	.5855
Offers functions to solve tasks efficiently	4.4848	.75503
Self-Descriptiveness (helpfulness)		
Provides a good overview over its functionality	4.5000	.62217
Use clear terms in the instructions	4.5455	.61699
Controllability		
Offers an opportunity to stop the task and continue at the same point later on	4.4545	.61699
Suitability for learning (learnability)		
Requires a very little time to learn operating the application	4.4242	.79177
Makes you memorize the things that you learned better	4.4545	.66572
Easy to learn without somebody help or manual	4.4063	.97912
Make me wants to know and learn more	4.6970	.52944

There are two questions asked to measure how efficient the application; easy to use and offer functions to solve tasks efficiently. Both items were very high with 4.69 and 4.48 on a scale from 1=worst to 5=best. It shows that even most participants were experienced with AR application in the first time but they feel that this application is easy to use and the AR prototype is offering the functions to solve tasks efficiently. For the other questions using the same scale measurement, the AR prototype is also being very helpful for the user as the two items are also consider high (4.5 for providing a good overview over its functionality and 4.54 for using clear terms in the instructions). Moreover, user control of the system is also high as the system offers an opportunity to stop the task and continue at the same point later (4.45 point). It means that user feel to have a control not being controlled of the system. The next four questions are concerned on the suitability of AR application for education. For the first time use, participants feel that it requires a very little time to learn operating the application (4.42 point), the instructions is clearly described and the way to operate the application do not require them to have any advanced computer skill. Participants also feel that using AR will makes them memorize things they learned better (4.45 point). It is because the visualization of the content being more attractive in 3D virtual objects where they can interact with it in real time world. It is also reported that participants feel it is easy to learn the application without other's help or manual (4.4 point), and they were being more excited to have AR application for learning (4.67 point).

V. CONCLUSION AND FUTURE WORK

The first study has been conducted to determine the familiarity of AR application use in learning environment, and the usefulness perception of AR application for education. The main findings in the study are:

- The familiarity of AR technology especially in daily learning environment considered low because most of the participants never experience with AR technology before, but they enjoyed and enthusiast having this kind of application for learning.
- Even the AR prototype in this first study only showed simple animation and limited interaction but the participants show a very good feedback and enthusiasm for the AR use in education.
- Several usability issues have been identified. Some issues such as the 3D visualization, interaction and the scenario should be enriched and improved to make the application more attractive.

For the further works, the design of the AR prototype in this study will be improved according to some issues in interaction design and user expectation based on the findings.

REFERENCES

[1] Azuma, R. (2004). Overview of Augmented Reality. SIGGRAPH.

[2] Chen, Y.-C. (2006). A Study of Comparing the Use of Augmented Reality and Physical Models in Chemistry Education. VRCIA 2006. Hong Kong.

[3] B.H. Guan, A.R. Zain, T.M. Ling (2002). Integrated Curriculum for Secondary Schools, Science Form 1. Volume 2. Berita Publishing Sdn. Bhd.

[4] J. Prümper and M. Anft, "Die Evaluation von Software auf Grundlage des Entwurfs zur internationalen Ergonomie-Norm ISO 9241 Teil 10 als Beitrag zur partizipativen Systemgestaltung - ein Fallbeispiel," in *Software- Ergonomie '93: Von der Benutzungsoberfläche zur Arbeitsgestaltung*, K. H. Rödiger, Ed. Stuttgart: Teubner, 1993, pp. 145-156.

[5] Nilsson, S. and B. Johansson (2007). Fun and Usable: Augmented Reality Instructions in a Hospital Setting. OzCHI 2007, Adelaide, Australia.

[6] Squire, K. D., M. Jan, et al. (2008). Wherever You Go, There You Are: Place-Based Augmented Reality Games For Learning.

[7] Dünser, A. and E. Hornecker (2007). Lessons from an AR Book study. TEI'07 Baton Rouge, Louisiana, USA.

[8] Awang Rambli D.R., Sulaiman S., Nayan M.Y. (2007). A Portable Augmented Reality Lab. 1st International Malaysian Educational Technology Convention, Nov 1-6 2007, Skudai, Johor

[9] Nischelwitzer, A., F.-J. Lenz, et al. (2007). Some Aspects of the Development of Low-Cost Augmented Reality Learning Environments as Examples for Future Interfaces in Technology Enhanced Learning. Universal Access in HCI Part III, 2007.

[10] Kaufmann, H. (2002). Construct3D: An Augmented Reality Application for Mathematics and Geometry Education. Multimedia'02.

[11] Kaufmann, H. and A. Dünser (2007). Summary of Usability Evaluations of an Educational Augmented Reality Application. Virtual Reality, HCII 2007.

[12] Kaufmann, H. and D. Schmalstieg (2002). "Mathematics And Geometry Education With Collaborative Augmented Reality."

[13] Oh, S. and W. Woo (2008). ARGarden: Augmented Edutainment System with a Learning Companion, Springer-Verlag Berlin Heidelberg.

[14] S. A. C. James C. Lester, Susan E. Kahler, S. Todd Barlow, Brian A. Stone, Ravinder S. Bhogal, "The Persona Effect: Affective Impact of Animated Pedagogical Agents," in *Conference on Human Factors in Computing Systems*, Atlanta, Georgia, United States 1997, pp. 359 - 366.

[15] V. A. D. John P. Chin, Kent L. Norman, "Development of an Instrument Measuring User Satisfaction of the Human-Computer Interface," in *Conference on Human Factors in Computing Systems*, Washington, D.C., United States 1988, pp. 213 - 218

[17] O'Brien, H.L. & Toms, E.G., "Engagement as Process in Computer-Mediated Environments," in Proceedings of ASIS&T. Charlotte, North Carolina, 2005.

[18] Hix, D., Gabbard, J., Swan, E., Livingston, M., Herer, T., Julier, S., Baillot, Y. & Brown, D.: A Cost-Effective Usability Evaluation Progression for Novel Interactive Systems, In *Proceedings of the Hawaii International Conference on Systems Sciences*, January 5-8, 2004, Big Island, Hawaii.)

[19] C. Bach and D. L. Scapin, "Obstacles and Perspectives for Evaluating Mixed Reality Systems Usability," presented at Workshop MIXER "Exploring the Design and Engineering of MR system", IUI-CADUI 2004, Funchal, Island of Madeira, Portugal, 2004.