A REVIEW OF THE FEATURES OF AUGMENTED REALITY SCIENCE TEXTBOOK

[1]Valarmathie Gopalan, [2]Abdul Nasir Zulkifli, [3]Nur Fadziana Faisal Mohamed, [4]Asmidah Alwi, [5]Ruzinoor Che Mat, [6]Juliana Aida Abu Bakar and [7]Aeni Zuhana Saidin

Universiti Utara Malaysia, MALAYSIA.

[1]valarmathie@rocketmail.com, [2]nasirzul@uum.edu.my, [3]fadziana@uum.edu.my, [4]asmidah@uum.edu.my, [5]ruzinoor@uum.edu.my, [6]liana@uum.edu.my and [7]aeni@uum.edu.my

ABSTRACT

This paper reviews several literatures concerning the features of Augmented Reality (AR) based textbook that could be applied for science learning in schools in order to make the learning process effective and interesting. The intervention of AR in science textbook could bring a tremendous impact on students' attitude towards the science subject. Even though there are several other proven and astonishing technologies for learning, AR has been chosen because of its highly potential and immersive characteristics. AR overlays real and virtual environment and displays them simultaneously on a computer screen. This technology offers students with the ultimate imaginary and makes them feel the real experience with scientific concepts which is impossible to experience in real life. This paper identifies several interesting features that could be applied in science textbook. These features are able to cultivate positive attitude and motivate the students to perform well in the science subject. Even though, the existing textbook is comprehensive, there are some limitations that might influence students' performance in the science subject. By adding some additional features into the textbook, it could overcome the limitations and motivates the students in the learning process. This paper will be of interest to researchers in the areas of Augmented Reality in education as well as science teachers in general. This paper aims to introduce AR based textbook so that it can be widely used in schools especially for science learning so as to motivate students to be more interested in science. The information about the features of Augmented Reality (AR) based textbook that have been discussed in this paper will hopefully be a very useful guidance for other researchers as well as science teachers in planning and developing their own AR based textbook.

Keywords: Augmented Reality in Education, Science Textbook, AR Features

INTRODUCTION

Through Vision 2020, Malaysia has to be a developed and fully industrialized nation by the year 2020. By then the nation is expected to explore, discover, capture, and monopolize a variety of disciplines and natural wealth. As a developed nation, mastery in science and technology fields will enable Malaysia to build the strength to be competitive with other developed countries (Rahim, 2012; Aikenhead, 2005).

As such, science learning should be given more priority (Talib et al., 2009) because it plays a major role in assisting a country to achieve the developed country status. Moreover, science and technology is the fundamental force behind the economic development of developing nations (Rahim, 2012). However, Malaysia is facing a downward trend over a few decades in pursuing science related profession and careers by younger generations (Osman et al., 2006). In the mid 80's the ratio of students interested in science compared to the arts was 31:69; 22:78 in the 1990's and 20:80 until 2012 (Teh, 2013).

School is the first platform where students learn science. The achievement and progress in science learning during school period is very prominent and must be given more priority. Even though, with all the advances in educational technologies, the teaching and learning processes in schools are still based on conventional methods. Nothing can replace a teacher and textbook contributions in gaining knowledge in a classroom environment. Thus, for a more sustainable and effective learning sessions, some unique features should be included in the existing science textbooks. Even though comprehensive science textbooks are provided in schools, supplementary learning materials are still required because some dynamic concepts are difficult to explain in the traditional method of teaching (Hwang et al., 2012). Thus, an advanced learning material with technology is required.

CURRENT SCIENCE TEXTBOOK

Textbook is the primary source of reference for knowledge in a classroom science learning environment in Malaysia. The existence of textbooks in a learning process is still widely welcomed because of certain criteria such as transportability, mobility and robustness (Marshall, 2005; Grasset et al., 2008). However, some limitations of the textbooks have been identified as cause of low achievements among students (Nincarean et al., 2013). These include textbook's incompetence in conveying certain terms in 3D model and in transforming time related information in an animated manner such as motion (Nincarean et al., 2013) and textbook's non-interactive features such static text, 2D colour images and simple illustrations (Abas & Zaman, 2009). In order to overcome the limitations, this study proposes the intervention of technology through the addition of Multimedia (MM) elements such as video, 3D objects, animation and audio to the existing science textbook as recommended by researchers and academicians. Besides that, this study will also try to simplify some complex terms which are difficult to be explained in the conventional teaching and learning method.

AUGMENTED REALITY (AR) IN SCIENCE LEARNING

AR is one of the technologies that hold a lot of potential in science learning. AR allows the computer to generate virtual imagery to exactly superimpose physical objects in real time (Zhou et al., 2008). Additionally, AR generates a coalition which brings closer the virtual elements and real elements simultaneously on the computer screen with additional multimedia elements such as audio, video and graphics based on the real world perception (Yuen et al., 2011).

AR enhances the users' perception with the real world, stimulates creative thinking and enhances students' comprehension towards the subject (Billinghurst & Dunser, 2012) and provides a multisensory learning environment which constantly engages students in the learning process (Zainuddin et al., 2009). AR has made a positive impact among the students in term of performing effectively in class assessments (Lee, 2012). Apart from that, AR successfully combines the education and entertainment activities together, which motivate the students to perform well (Lee, 2012).

AR offers the first-hand experience in science learning which cannot be experienced through the traditional teaching and learning method (Shelton & Hedley, 2002). AR is capable of engaging the user to discover the resources and apply it in the real world that has never been implemented before (Kerawalla et al., 2006). AR has been proven to have the ultimate potential in providing a better and effective learning experience to students in the classroom (Johnson et al., 2010). AR has its own exclusive touch in education which exposes a solitary and an active learning environment (Zainuddin et al., 2009). Many professionals and researchers have suggested applying AR to learning, especially for the subjects like Chemistry (Chen, 2006; Fjeld & Voegtli, 2002; Nunez et al., 2008), Physics (Chae & Ko, 2008; Buchanan et al., 2008; Enyedy et al., 2012; Andujar et al., 2011) and Astronomy (Sin & Zaman, 2009; Shelton & Hedley, 2002).

AUGMENTED REALITY SCIENCE TEXTBOOK

The Intervention of AR technology through the addition of Multimedia (MM) elements in the existing science textbook could bring a tremendous impact on science learning and eventually on learner’s attitude towards the science subject. Since AR is very useful for science learning, it can be implemented in the form of markers which will be pasted or printed on the pages of the science textbooks. Whenever, the marker is held in front of the webcam, students can view the virtual contents consisting of multimedia elements such as videos, 3D objects, animations and audio attached to the markers. The virtual contents enable the students to visualize and understand simple to complex science concepts. Students are able to interact with the digital contents especially the 3D models by manipulating the markers. The AR implementation can be categorized as; Interactive AR Book (Clark & Dunser, 2012; Dunser, 2008; Grasset et al., 2007), Augmented Book (Martin-Gutierrez et al., 2010; Yang et al., 2009), Pop-Up Book (Vate-U-Lan, 2011), and Mixed Reality Book (Grasset et al., 2008). Moreover, utilizing AR in science textbook could help the learners to develop better investigation skills (Sotiriou & Bogner, 2008) and gain more accurate facts on the topic. AR alters the normal textbook to magical book (Lee, 2012) and provides a responsive and sensible learning environment (Billinghurst et al., 2001).

FEATURES OF AR BOOK

In developing the AR book, there are many features that have been applied by previous researchers. In this paper, we only focus on the features of the content that have been implemented in the previous AR books.

The features have been classified according to the multimedia elements which include; text, audio, video, graphic, and animation; and also 3D model as shown in Table 1. Text, audio, video, graphic, and animation are five multimedia (MM) elements which are able to provide useful and multi-sensory learning experience. Additionally, a 3D model also delivers an in depth and an interactive learning experience. Many researchers have conducted plenty of researches on implementing MM elements, 3D models and AR technology in educational books. The aim of this review is to identify the most popular features which have been used in AR Books. Furthermore, each features has its own unique characteristic which is able to provide attractive and interactive learning experience.

Text

Text is the most widely used and flexible means of presenting information on screen and conveying ideas. Text plays a prominent role in presenting the information. Most multimedia systems use a combination of text and other elements to deliver functionality. Text in multimedia systems can express specific information, or it can act as reinforcement for information contained in other media items. As suggested by Alessi and Trollip (2001), text layout, text format and text quality are a salient part of a project.

Graphic

According to Alessi and Trollip (2001), four major applications of graphics include; primary of information, analogies or mnemonics, organizers and cues. In MM, graphic is the visual presentations on some surface. The use of graphic establishes attraction, communication and direct attention to the users. Usually, the use of graphic in a textual information delivery promises better memory retention to the users. Moreover, difficult information that needs users' understanding is better projected and understandable by using graphic presentation (Schar & Krueger, 2000).

Audio

Audio plays a major role in some multimedia systems. In previous research have pointed out that audio has obvious advantages for presenting simple material to learners as an alternative to printed text for users that have poor reading skills (Dunser, 2008). Audio can attract user's attention away from his or her current task. The combination of visual presentation with audio explanation also delivers information in an easily understood format (Mayer, 2001).

Video

Video can record a motion that occurs in the real world. Alessi and Trollip (2001) indicated that video can be entertaining, engaging and provoking. Digital video appears in many multimedia applications which include websites such as YouTube, Vimeo, Dailymotion and Vube. Similar to audio, websites can stream digital video to increase the speed and availability of playback. A study by Bueno et al. (2007) suggested that video can be incorporated into e-Learning to teach deaf students.

Animation

Animation is an excellent way to add visual impact to the multimedia presentation. Computer animation refers to any application which generates a series of frames so that each frame appears as an alteration of the previous one and where the sequence of

frames is determined either by the designer or the user (Bétrancourt & Tversky, 2000). Animations include interactive effects which allow users to engage with the animation action using their mouse and keyboard. Animated components are common within both Web and desktop multimedia applications. Animation can be classified as 2D and 3D animations.

3D Models

3D model displays an object in a form that appears to be physically present with a designated structure. The object is represented in various dimensions that include width, depth, and height. The advantage of 3D models over videos and images is that the user is able to get a really three-dimensional impression of the object. 3D model can be displayed as static object as well as animated object.

Table 1 comprises of 29 articles which have been purposely selected for this review. The articles described the features of the AR Books that have been studied by previous researchers. The review will solely focus on the features of the content that have been implemented in the previous AR books which include; text, audio, video, graphic, animation; and 3D model. Based on Table 1, few AR books have been proposed in an effort to integrate Augmented Reality technology into books. Some examples of the AR Books include; Digilog book (see Figure 1), 3D Popup Book (see Figure 2), Magic Book (see Figure 3) and AR Haunted Book (see Figure 4).

The main purpose of this review is to determine the most popular features of the content of AR books. Based on Table 1, all the features of the content somehow have been implemented in the AR books. The most popular feature is 3D models (22), followed by graphic (16), animation (13), text (12), audio (9) and the least popular is video (6). 3D model is the most used feature in most of the reviewed articles related to AR Books. This feature has spectacular criteria which delivers attractive and interactive learning. Furthermore, an interactive learning environment with 3D models and animated content able to convert a passive learning environment into an active learning environment (Moore et al., 2007; Dufresne et al., 1996). Moreover, implementation of this feature provides an engaged and knowledgeable learning (Beeland, 2002).

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

Table1 Features of AR Books

Author/year	Content Features of AR Book						Name of the AR Book
	Text	Audio	Video	Graphic	Animation	3D Model	
Abhishekh et al.,2013					*	*	AR Book
Mahadzir et al.,2013	*	*		*	*		Pop-up Book
Rambli et al.,2013					*	*	AR Alphabet Book
Dunser et al., 2012					*	*	AR Physics Book
Matcha & Rambli, 2012	*			*		*	AR Book
Rambli et al., 2012	*	*			*	*	AR Storybook
Setozaki et al.,2012			*			*	AR Astronomy Textbook
Clark et al.,2012				*		*	AR Colouring Book
McGrath et al., 2011						*	AR Etnobotany Workbook
Margetis et al., 2011	*						SESIL AR Book
Simeone et al.,2011				*		*	REFF Book
Vate-U-Lan, 2011	*	*		*	*		3D Pop-Up Book
Choi et al.,2010; Ha et al.,2011	*		*	*		*	Digilog Book
Dias et al.,2009	*	*		*		*	miBook
Martin-Gutierrez et al., 2010						*	AR-Dehaes
Sin and Zaman, 2010	*		*	*		*	Live Solar System AR Book
Lee et al., 2009		*	*	*	*		*Not Mentioned*
Yusoff & Zaman, 2009		*				*	MRTE Book
Zainuddin et al., 2009	*			*		*	AR SiD
Grasset et al.,2008		*			*	*	Mixed-Reality Book
Scherrer et al., 2008				*	*		AR Haunted Book
Dunser & Hornecker, 2007	*	*	*	*	*	*	AR-Jam
Taketa et al.,2007				*	*	*	Virtual Pop-up Book
Chen, 2006						*	AR Protein Magic Book
Ucelli et al.,2005			*	*		*	Book of Colours
McKenzie & Darnell, 2003					*	*	Eye Magic Book
Back et al., 2001	*	*		*			SIT Book
Billinghurst et al., 2001	*			*	*	*	Magic Book
	12	9	6	16	13	22	

Figure 1 Digilog Book (Ha et al., 2011)

Figure 2 3D Popup Book (Vate-U-Lan, 2011)

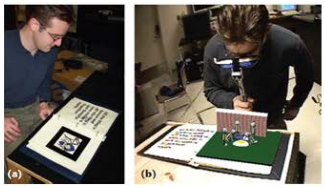

Figure 3 Magic Book (Billinghurst et al., 2001)

Figure 4 AR Haunted Book (Scherrer et al., 2008)

CONCLUSION

This paper reviewed 29 articles which described the features of AR Books. These features are expected to be able to explain complex scientific terms, processes and phenomenon easier compared to the traditional method of teaching. Based on this review, the most popular feature is 3D models (22), followed by graphic (16), animation (13), text (12), audio (9) and the least popular is video (6). This paper aims to introduce AR based textbook so that it can be implemented widely in schools especially for science learning so as to motivate students to be more interested in science. Based on this review, we will incorporate the features identified in this paper into the design and development of the science textbook through the use of AR technology in a real classroom environment. It is hoped that the intervention of AR in textbooks, particularly in science subject could enhance the students' motivation towards science learning. This review will be of interest to researchers in the areas of Augmented Reality in education as well as science teachers in general. The information about the features of Augmented Reality (AR) based textbook that have been discussed in this paper will hopefully be a very useful guidance for other researchers as well as science teachers in planning and developing their own AR based textbook. This review is not comprehensive since new and more sophisticated techniques are continuously being developed and the discussions on the other features are beyond the scope of this paper.

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