Augmented Reality Books For Science Learning-A Brief Review

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Abstract—Science plays a major role in assisting Malaysia to achieve the developed country status by 2020. As such, the government introduces the 60:40 (science: arts) education policy. However, statistics and studies indicated that Malaysia is facing a downward trend in the number of students pursuing science. School is the first platform where students learn science. However, science learning in schools is still based on the conventional methods. In order to motivate the students towards science learning, a new approach of learning needs to be introduced. The intervention of Augmented Reality (AR) in science could bring a tremendous impact on students' attitudes towards science learning. This paper reviews several past studies related to the intervention of AR in science books and describes the unique features of some of the books. It is hoped that more AR science books shall be developed incorporating these unique features to make science learning more interesting to the students. This will leave a great impact on students and motivate them to pursue their career and higher education in science related fields. This paper will be of interest to researchers in the areas of AR in education as well as science teachers in general.

Keywords— Augmented Reality, Science Learning, Features, AR Book

Through Vision 2020, Malaysia is determined towards becoming a developed nation by the year 2020. In order to achieve the target, there will be a tremendous need for qualified and certified workforces in science related fields. They will play the roles as researchers, scientists, medical doctors, specialists, technologists, engineers, architects, designers, and lecturers. This is in line with the strategy of the Ministry of Education (MoE) which introduced a policy of 60:40 whereby it is the targeted ratio of science to art students. This policy is closely linked with the efforts to make Malaysia as a developed nation by 2020 which has been introduced in the late 80's [11]. Furthermore, based on a study conducted by the MoE, it was reported that there was a serious reduction in the number of students majoring in science with only 29 percent [29], [11]. This is far from the 60 percent that has been targeted for science and 40 percent for arts and humanities [29], [11]. Due to the drastic reduction in the percentage of students pursuing science compared to the arts, the former Deputy Prime Minister Tan Sri Muhyiddin Yassin has ordered the establishment of a special committee to identify the causes and possible solutions to this issue [11]. Meanwhile, according to Prof. Dr. Halimaton Hamdan, the science stream students in local universities were only around 35,000 a year, where it should be 100,000 a year [25]. As Malaysia is moving towards becoming an industrialized nation, there is a crucial need for more science-based graduates to achieve the target [24], [28]. The MoE has reported the deterioration issue of the students' interest in Mathematics and Science, whereby only 37 per cent for Mathematic and 29 percent for pure Science [11]. This circumstance occurs due to the lack of upgrading learning materials parallel to the time being. This is because the younger generations are exposed to various forms of learning resources which are not only restricted to text and image alone. Instead, they have exposed to multimedia (MM) elements such as video, audio and 3D animation which can be accessed through the internet, CD/DVD and various other sources. The current generations are born with technology and grow up with gadgets [4], [23]. Therefore, science learning in schools should be complemented with these elements in order to be up-to-date with the latest learning trends and at the same time to stimulate students' interest in the subject [22]. 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 session, 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 [1], [14], [22].

Therefore, AR technology is proposed with the addition of MM elements to enhance the interest in science. There are many other verified and extraordinary technologies, indeed AR's potential in the educational field which has been proven in the previous studies by researchers is the main reason for implementing AR in the educational environment and real classroom environment [16],[18]. According to [31], AR has its own unique touch in education which exposes a solitary and an active learning environment. AR has proven its ability by partaking in and motivates students in the learning process for a long time [8], [16]. Furthermore, science leads students to think in a different angle in solving the scientific problems. This offers unique affordances, combining physical and virtual worlds, with continuous and implicit user control of the point of view and interactivity. The ability to overlay computer graphics into the real world is commonly called AR. Unlike immersive Virtual Reality (VR), AR interfaces allow users to see the real world at the same time as virtual imagery attached to real locations and objects with the 3D

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information in a natural way like they do in the real environment. This paper reviews several past studies related to science learning through the intervention of AR which can be utilized to enhance student's interest in science.

2 AUGMENTED REALITY

AR has been used in developing systems with learning purposes [15], [16], [18]. AR has been exposed to the military; medicine; engineering design; robotic; telerobotic; manufacturing, maintenance and repair applications; consumer design; learning; entertainment; edutainment and psychological treatment domains [2], [3], [5]. AR displays information through the virtual objects that the user cannot directly detect with his/her own senses, which enable a person to interact with the real world in ways never before possible. The virtual objects are able to change the position, shape, and other graphical features through the interaction techniques that AR supports. The information conveyed by the virtual objects helps user's present real world tasks. The Tangible Interface Metaphor is one of the important ways to improve learning. The AR applications based on this metaphor are more similar to the natural face-to-face collaboration than to screen based collaboration [7].

Furthermore,[6] presented the very first AR Book named Magic Book. It seems like a normal book, but in the pages are markers and when the system recognizes a marker, the virtual content is displayed on the screen. Through the use of AR in printed book pages, books will become the dynamic sources of information. In this way, people with no computer background can still have a rich interactive experience [7].

3 AR BOOK FOR SCIENCE LEARNING

The potential of AR in the learning process, especially in science learning has been accepted and acknowledged by researchers in the previous studies. Moreover, specialists and researchers in the field counseled AR to be utilized for the subjects like Chemistry [21], Mathematics [9], Physics [10] and Astronomy [26]. AR book can be used either as an ordinary book without the intervention of technology or with the intervention of technology as AR enhanced book. This method of AR implementation has several names which include; Magic Book [6]; Interactive AR Book [12]; Augmented Book [19]; Enhanced Textbook [17]; Flip Book [12], Pop-Up Book [30] and Mixed Reality Book [13].

Besides that, the Institute of Multimedia Education in Japan has developed the first AR textbook for mathematics instructional material and a museum display system [17]. There are several selected studies which are related to science learning which are discussed in this paper. Fundamentally, AR technology with the addition of MM elements is commonly being implemented in science based subjects such as Physics, Chemistry, and Science among various groups of users. With the capability of infusing digital information throughout the real world, AR technology could engage learners in an immersive context along with authentic experiences to make scientific investigations, collect data outside the classroom, interact with an avatar, or communicate face-to-face with the peers [9]. The following sub-sections discuss the features of several AR books in science learning and attention need to be focused on how the books could further enhance the students' interest in science learning.

3.1 Magic Book

[6] studied the use of Magic Book for science learning. The Magic Book interface consists of a handheld AR display (HHD), a computer graphics workstation, and the physical book as shown in Figure 1 (a). Users have their own handheld display and computer to generate their individual scene views. These computers are networked together to exchange the information about the avatar positions and the virtual scene each user views. The low cost and ease of use make the Magic Book interface an attractive means of viewing almost any spatial data. Applications that involve moving between exocentric and egocentric views of a data set could benefit the most from this approach [6]. The book is a normal book with text and images and some of the images are with a thick black rectangle. So that, the user can view the virtual content using HHD [6].

3.2 AR system and physical model

This study applied AR in chemistry. This system was developed at the Human Interface Technology Laboratory (HIT Lab) and it requires only a laptop and a webcam to render all the virtual objects. The participants can choose either the AR markers or the physical models when they studied the five amino acids [7]. Through this kind of body learning, students are able to experience the first-hand real experience which they cannot experience in the real world [7], [8], [16]. Participants in this study possessed basic chemistry knowledge, such as basic chemical representations. During the learning process, all participants used AR markers and physical models interchangeably to observe the structure of the amino acids as shown in Figure 1 (b). When using the physical models, they manipulate the physical model in their hand like rotate it and count the number of specific atoms. These two phenomena imply that AR created an intuitive interface for the participants to interact with the amino acid [7]. In this study, there was a qualitative research method was applied. The participants were undergraduate students who register for "Organic Chemistry" course.

3.3 AR Human Body System

The system consists of an AR system for learning anatomical structures in a human body [15]. Tangible interfaces have been used to interact with the system. The system requires the origin of the coordinate system in order to place all elements. This is achieved by placing a marker is one corner of the square structure. In the system, the hands are detected and shown over the merged image as shown in Figure 1 (c). This system can be viewed through the Head Mounted Display (HMD) Visualization System as well as through the monitor. There are no statistical significant for both methods of learning indeed, the children were enjoying the AR intervention in their learning process.

3.4 AR Notes

It is an AR exercise book that can be used at home [23]. Secondary school students were participating in this study. The basic idea was to integrate the AR markers into the self-made lesson plan and implemented in the Chemistry subject. The goal was to represent a successful example of AR technology and combine a classic student book with the new 3D models as shown in Figure 1 (d). This paper

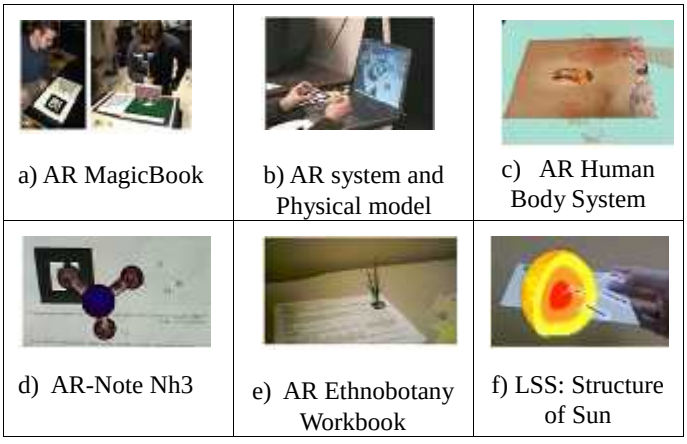
proposed the relevance of AR and presents how the intervention of technology assists in a learning process [23].

3.5 AR Ethnobotany Workbook

This AR book depicts a simple AR Book about Ethnobotany [20]. It provides a low-cost AR book which requires a desktop and webcam to present the virtual content. The content is based on plants and whenever the markers are held in front of the webcam, the 3D content for each plant will be displayed on the screen as shown in Figure 1 (e). Since this is a simple desktop application, it is can be used in the classroom and also out of the classroom environment. This workbook demonstrates the great potential of AR in science learning and is one of the good examples of the initial implementation of AR technology in formal education.

3.6 AR Book: Live Solar System (LSS).

Researchers have been implementing AR in Astronomy and an example of the AR application is Live Solar System (LSS) [27]. This system depicts the relationship between the earth, the sun, the stars and the galaxy through the use of the AR technology as shown in Figure 1 (f). The application provides an intuitive - tangible interface for its user through the use of a cube for the physical interaction. The animation of the virtual content will be displayed by manipulating the cube. This system was tested using three measurements, namely, ease of use, learnability, and effectiveness. Based on the evaluation, it has been proven that the LSS is easy to use and useful in Astronomy learning.



a) AR MagicBook | b) AR system and Physical model | c) AR Human Body System

d) AR-Note Nh3 | e) AR Ethnobotany Workbook | f) LSS: Structure of Sun

Fig1. Example of AR Books

4 CONCLUSION

In this paper, several works related to AR books for science learning developed by previous researchers have been reviewed. It also discusses some of the features of the books and how they could be applied in enhancing the students' interest in science learning. These features are expected to be able to explain complex scientific terms, processes and phenomenon easier compared to the traditional method of teaching. This paper aims to introduce AR books from previous literature so that it can be implemented widely in schools especially for science learning so as to motivate students to be more interested in science. AR offers low cost and ease of use applications whereby they can be used in the classroom and also out of the classroom environment. The AR interfaces provide an attractive means of viewing almost any spatial data with seamless interaction between the real and virtual worlds. Using the AR books, learners interact with the 3D information, objects and events in a natural way.

In addition, AR also provides the use of tangible interface metaphor for object manipulation. Besides providing previous works on AR books for science learning, the reviewed articles also provide several directions of research. However, due to the fact that studies of AR books for science learning are still in their infancy, the number of selected articles may be a limitation. This paper will hopefully be a very useful guidance for other researchers as well as science teachers in planning and developing their own AR book. 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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