Augmented Reality: A Review on Its Issues and Application in Teaching and Learning

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***Abstract*— Augmented Reality (AR) is one of the cutting-edge technology which allows users to have a digitally enhances view of the reality world by rendering the 3-D virtual objects. By deploying camera and sensors, AR adds layers of digital information such as videos, photos, sounds directly on top of items in the world around us, providing users platform to interact with virtual and real objects at the meantime. The implementation of AR in formal education will be a leading component in the coming learning environment which incorporates hardware and software applications. The purpose of this paper is to provide broad study on AR technology and presents a review on the fundamental concepts of AR. Besides that, this paper will also discuss the current AR applications that are used on learning and teaching process. Some related issues of AR in the education field including some of the challenges faced in promoting the use of AR will also be explained.**

Keywords*— Virtual Reality, Augmented Reality, Teaching and Learning, AR Application*

I. INTRODUCTION

A new augmented reality browser which is implemented into Google Glass called Junaio Mirage has been introduced. It reflects that augmented reality nowadays has been receiving more and more attention. Augmented Reality is defined as a system of tools that allows a person to view a virtual 3-D objects and it is said to be similar to the concept of Virtual Reality (VR). Instead of immerse in the complete virtual world created in VR, the concept of AR is to integrate the virtual view with the real world environment [1]. AR falls somewhere between a fully computer generated world that is VR and the real world. The real world is said to be "augmented" since virtual objects are overlaid onto the real world image [2]. In simple words, the users are aware of the surrounding environment changes while exposed to the AR objects created.

AR works in a way that images of the real world are captured by a camera with images of virtual objects superimposed onto it. Not only can the user see the images, the VR can also be manipulated. The AR technology uses pattern recognition to detect and prepare the virtual models by matching it with known patterns stored in the database. Markers are often used which could be as simple as print on a paper or real objects. With this, the user can move the marker in real life and affects the VR projection of the object. [2]

AR has been introduced in a broad scope of education, including discovery learning. Jerome Bruner, who furthered the notions of discovery learning in the 1960s, believes that "Practice in discovering for oneself teaches one to acquire information in a way that makes that information more readily viable in problem solving,'" (Bruner, 1961) Many early versions of portable AR illustrate the ability to enhance a live experience through discovery based learning. For instance, a visitor to an art gallery, museum or historic site can access AR applications that enable additional information, maps, audio content, or videos.

Relating to AR in classroom learning process, the trend is evolving towards incorporating more software applications. AR as the emerging technology is foreseen to have positive impacts on education fields. [3]Teachers are able to show virtual 3-D objects to students instead of explaining in plain words and asking for imagination. Students are allowed to have a direct visual view on the objects regarding on the teaching lessons. A bundle of AR based applications have hence been developed to aid in learning process.

Viewing the potential of AR technology in our daily life especially in education fields, the objectives of the paper including to study and review the use of AR based applications in education including the acceptance of students over the applications used as well as to uncover the challenges faced in implementing AR application in education.

The remaining parts of the paper is organized and separated into several parts. In Section II, we outline the related and existing works on AR technology. Section III includes the analysis on the existing AR based application, exploring its usage and discusses the progress of AR technology in education field. We address the issues of AR in education in Section IV including the challenges and general reliability. Last but not least, we conclude and include our future works in Section V.

II. Related Work

The research on AR technology had been conducted extendedly on various education fields. The implementation of AR technologies can assist students explore the multidimensional augmentation of teaching materials in various levels of details. Students can navigate through the augmented information and, therefore, concentrate and study in detail any part of the teaching material in different presentation formats, thus enhancing understanding.

Liarokapis and et al (2004) [4] proposed an AR application on engineering and design that has been experimentally designed to support the teaching and learning of mechanical engineering concepts such as machines, vehicles, platonic solids and tools. By implementing Web3D and AR technologies, the system allows users to create and deliver multimedia teaching. The design of the system uses the interaction of 3D Web content (Web 3D), virtual and augmented reality in the same web-based learning support application and AR presentation scenarios to improve students' understanding. Through the use of the system, students were able to be exposed to the virtual object created and hence visualize how a camshaft is arranged in relation to other engine components as well as other components such as the tappets, follower, etc. arranged as they might be with an engine. AR is useful in aiding students as they can examine the real components at the same time manipulate its virtual counterpart. The use of Web3D creates an environment that augments traditional teaching material using high quality images, 3D models single or multi-part models. Students will be able to better understand aspects of the teaching material that is not evident in the pictures through the use of 3D model because they are hidden.

AR technology can also be used in the teaching of Chemistry as it can provide students with the necessary view and visualization needed especially in the representation of molecular models. Chen (2006) [5] wrote a paper comparing the use of AR & physical model in education and compared the effectiveness of using augmented reality and physical models in teaching chemistry. The students who participated in the research think that it is easier to project AR-generated images on the screen so that each and every one could see the AR virtual objects at the same time instead of passing the physical model around. Pasaréti and et al [6] created an AR technology-based high school lesson that uses an AR-exercise book in teaching Chemistry to high school students. The system involves the use of AR-technology to produce a 3D representation of molecular structure for a more interesting and interactive learning for the students. The feedbacks provided by the students indicated that they were able to understand the pictures on board or in the books better through the use of AR and most of them gave positive opinions.

Sašo Zagoranski and Saša Divjak (2003) [2] proposed the use of AR in aiding students as a substitute for the lack of real equipment especially in the case of distance learning. The use of AR replaces real experimental whereby the virtual laboratory could be obtained from the internet or on a CD. Through this method, students are able to work at home and the limitation of distance learning could be reduced. The participants could utilise videoconferencing with fellow students or teachers with AR. The study by Liarokapis and et al (2002) [18] discusses the use of Multimedia Augmented Reality Interface for E-learning (MARIE) especially its application for engineering education. Its primary focus is the potential of AR by superimposing Virtual Multimedia Content (VMC) information in an AR tabletop environment. It is low cost and real-time augmented presentation. The implementation of the system will create a generic platform applicable to a variety of other teaching and learning AR environment.

III. AR Applications in Education

Some of the most exciting augmented-reality work is taking place in research labs at universities around the world. In February 2009, at the TED conference, Pattie Maes and Pranav Mistry presented their augmented-reality system, which they developed as part of MIT Media Lab's Fluid Interfaces Group. This reflects the continuous development and research of AR in education. The following part of section will discuss several existing AR based application in assisting educators in teaching and learning process.

CONSTRUCT3D

In order to fill the gap of next-generation virtual reality interface for Mathematics and geometry education, a 3-D geometry construction tool with name Construct3D was developed. [8] The system deploying AR to allow a natural setting for face-to-face collaboration of teachers and students. By offering a basic set of functions including intersections, Boolean operations, normal lines and planes, symmetry operations, and taking measurements, Construct3D allows the construction of primitives such as points, lines, planes, cubes, spheres, cylinders and cones. In conjunction with the current education policy, Construct3D tries to promote and support exploratory behavior through dynamic geometry.[6]All

geometric entities can be continuously modified while dependent entities retain their geometric relationships.

In overall evaluation from technical aspect as well as orientation aspect, Construct3D is one of the leading AR based application in mathematics and geometry education. It supports various learning styles and provides hybrid hardware setups for classroom use. Students may work alone and together or having a teacher to work with a group of students in implementing this application. Besides that, as the schools authorities may not able to afford extensive installations of expensive equipment, the software also able to be run on a variety of immersive and non-immersive hardware platforms including heterogeneous and hybrid setups.

Fig. 1: Construct3D Model [9]

Aurasma

Aurasma allows users to engage in and create Augmented Reality experiences of their own. Educators and students can use this open source tool to essentially bring their learning to life. Aurasma application uses advanced image recognition techniques to augment the real world with interactive content such as videos, 3-D objects and animations which associated to trigger images or videos. [10]The Aurasma Studio is a free online platform which assists the teachers to create and publish their own AR information in an intuitive and user friendly environment. It requires no programming knowledge and background and hence teachers can easily upload trigger images that can be associated to videos, images, 3-D or other information. [7]

This is an easy-accessed application in which can be downloaded from application stores on smart phones. It can be used in various ways in classroom activities. For example, when students scan a page of their home work, the page will reveal a video of the solution given by their teachers. Students may also record their brief review on a novel or book that they have studied and attached that "aura" (assigned digital information) to the book. The latter reviewers can scan the book cover to instantly access the review. It may also promote parent involvement in children education phase by recording their brief words of encouragement to their child. A trigger image will then be attached to the child's desk and they may scan the image for virtual inspiration. While conducting experiment in laboratory, teachers may put triggers all around a science laboratory so that when students scan them, they can quickly learn the different safety procedures and protocols for the lab equipment.

Fig. 2 : Aurasma [11]

Augmented Chemistry

Augmented Chemistry is the realization of an in-house designed Tangible User Interface (TUI). [12]A set of interactive tools embedded in this system. Users can choose elements from a booklet of menu and composed into 3-D molecular models. Each tool is indicating a way towards comprehending a seamless integration of the physical and digital domain. Multiple users are allowed to interact with the system at the same time in which enhancing the learning process. The design and implementation of the Augmented Chemistry system is adapting the knowledge from optic, mathematics, molecular chemistry, software engineering as well as 3-D programming, converging into an interdisciplinary project.

The system is foreseen to be helpful in chemistry education. It provides a platform which offering its users to see and to interact with 3-D molecular models in an intuitive and direct way. Students are allowed to build composite molecular models of chemical on themselves by using the tools supported. They are able to pick up, position and compose each single atom into complex molecules. It thus enhances the understanding and knowledge of students on the molecule structures. Students are able to comprehend the teaching lessons better by viewing the molecules and bonds connected in all directions.

GeoGoogle

GeoGoogle is a free augmented reality app which assists geographic education in an interactive way. It benefits students in helping them to learn geographical measurements such as longitude and latitude. With GeoGoogle, students can easily mark their location, view direction from the 3-D compass incorporated in the application, check the speed of movement as well as view the shortest route to the destination. It also allows students to calculate altitude and the distance between two points using a 3D compass. Like other augmented reality apps, GeoGoogle also uses overlay graphics

combined with real-world surroundings to help students learn the fundamentals of geography.

Fig. 3: Example of GeoGoogle Screen shot

IV. CHALLENGES AND RELIABILITY OF AUGMENTED REALITY IN EDUCATION AND LEARNING

In this section, some of the significant challenges and reliability unique to the augmented reality collaborative in educational field will be discussed. The challenges can be broadly divided into three categories: (A) Pedagogical Challenge; (B) Technical Challenge; (C) User Acceptance Challenge.

A. Pedagogical Challenge

One of the notify advantage of augmented reality technology in education is that learners can actually 'see' and 'listen to' supplementary digital information and thus enhance the student learning interest and process. [14]Nevertheless, every page has two sides; student could be easily overloaded by the vast amount of digital information and teaching material that they encounter in the physical environment, thus, evoking cognitive overload by delivering too much information than can reasonably be processed by students. There is a risk that the proffered information may not be relevant yet the students may waste their time and effort in identifying those relevant resources and making them become overwhelmed with those resources. Thus, user-generated content is playing an important role when it is used to provide augmented reality. Creation of high quality and relevant content to support AR and location-based learning becomes significantly important. [15]

In the learning process, students are required to operate multiple technological devices and completed complex task given by their teacher. In other words, they have to be multitasking while collaborate AR with learning process. Students often felt overwhelming and confused with the teaching material and complexity of the tasks required to carry out during the simulation process as they have to handle the unfamiliar technology and tackle with the complex tasks at the same time.

Besides, multiple complex skills such as geo-spatial navigation, collaborative problem solving, technology manipulation, mathematical estimation may need to applied and synthesize by students when deal with completing the task in AR environment. [16]Student might lack of such skills to handle and complete the task in AR environment and this could be problematic. This might lead to students discriminate the implementation of AR technology into learning process.

As mentioned earlier, the use of augmented reality stimulates visualization which overlays objects in the virtual reality environment with the real world will be able to engage students in lessons. However, this blending reality could lead to students' confusions. Worst case scenario might happen; students might have the confusion and lose sight of where the virtual visualization end and reality begins. Students may experience losing track of the real world environment and this could be troublesome and not productive for learning process and could lead in a threat to students' physical safety. [16]Thus, it is crucial to consider learning objectives before considering integrate learning with AR. AR may not be the most effective learning aid all the time, sometimes, more traditional and robust technique may be more suitable to the learning process. This technology might also reduce students' observation skills and critical thinking as an immediate overlay of information will be provided when engaging AR in learning environment. [15]

B. Technical Challenges

Although AR have emerged for quite some time and is not a new technology, however AR is still expanding its usage in many others area especially regarding its educational applications. Currently, though AR is still new and captivating, the technology for creating and develop AR content is still limited and difficult. Notify and significant technical knowledge about AR is required for those teachers and students to create their 3D models for AR. Besides, setting up AR equipment and devices might be a complicated and time consuming process. When more devices are required, the risk of device failure becomes greater. The stability and flexibility using the AR courseware in the education will become critical issues to be discussed. Time consuming in setting up AR equipment process and failure fixing process will definitely reduce the precious learning time of students.

In hardware and software issues, students and educators reported that GPS error is the most troublesome. Most of the AR applications require GPS and digital compass to provide interesting rendering based on the location of the user. The image is said to be frozen and produce image registration error when the problem arises. This frustrating part encountered during the learning process will slow down the education progress. [16]However, this issue can be solved by the recent rapid advancement in portal and wireless technology. Besides,

the portable devices can have built in GPS, video camera, faster processor and large hard-drive memory to improve the stability of the devices when collaborate with the use of AR in simulation and GPS applications in educational field. [15]Internet access is typically required when using AR in learning environment. Devices using phone network yielding to varying quality of signal based on types of network being used. Setting up a local network may be necessary if tools require reliable network access. [15]Although this seems to be a good solution to solve the GPS error, but the cost of developing AR technology into the application is high as well. A lump sum of money has to be invested to develop those stability AR based courseware and devices.

Other concern includes, sometime AR based courseware application is too large and occupy too much of a mobile device's capacity. AR also involves intensive processing which might again lead to the image "frozen". Mobile devices have limited battery life, thus, students and teachers have to ensure that the battery have sufficient charge in order to complete and enhance the learning activity. [17]

C. User Acceptance Challenges

Aside of pedagogical and technical challenges, user acceptance elements must be consider as well as they are the one that will participate in using AR in education and benefit from it. A great portion of the problems faces was on the users' acceptance on the AR technology. As AR technology collaborating in education is still new, fancy and unfamiliar to most people, they do not know much on the operation of AR technology in education platform and the benefit that will bring to them.

There is a downside of implementing AR technology to remote laboratories which that students lack the feeling of real world and "touch", too abstract or not attractive although remote laboratories might be safer than the actual experiment laboratories. In term of accuracy and preciseness, users have their doubt on the outcome and result based on the remote experiment by using AR technology since they do not have the direct feeling of apparatus as well as the chemical used. [2]

By using AR technology in remote laboratories, student might feel that it is hard to control the stimulator to view the model in different point of view and this creating a feel of lack of user control when using the AR based courseware. The image might respond with several seconds delayed. Although there are a large number of students and educators find collaborating AR technology in education be fascinating and enhancing the learning process, but the number of rejecting the use of AR cannot be ignored as well. They prefer physical model and traditional way of learning over the virtual simulations as it is easier to manipulate and have high user control.

Besides, some users think that they are a possible of social issues encounter with the use of AR in education area. One of the most concerns is that AR may broaden the digital divide between learners. Mobile learning is becoming popular and AR is most commonly integrated with the use of advance and up to date mobile devices that are prohibitively expensive for some learners. The tension between innovative technologies such as AR and changing or maintaining practices for communities of users has been raised by [15].

V. CONCLUSION

Despite those challenges mentioned in section IV, the future of augmented reality is clearly bright, even as it already has found its way into the smart phones and video game systems. Like most technologies that eventually reach a mass market, augmented reality, or AR, has been gestating in university labs, as well as small companies focused on gaming and vertical applications, for nearly half a century.

Implementation of AR technology can be widely introduced to the education field. The usage of AR in education is not restricted to a particular subject or aspect. AR application allows the physical object to have virtual information tied to them, allowing students to control it in an intuitive way and collaborate and communicate in a more natural way within the physical environment, thus, students perceived the learning process as fascinating and fun.

In the future research effort, more evidence on educational values of AR should be provided by conducting controlled and comprehensive evaluation studies which include a large sample and valid instrumentation. In highlighting the features and affordances of AR technology in schools, researchers and developers should have persistent research on identifying effective curricular and technology characteristics which is uniquely to AR learning environment.

One of the great opportunities in AR technology is face recognition. In the relative infancy of development, it provides details of an individual when the application is held up to their face. This is generally achieved by matching facial features with information from the database. If face recognition technology was linked to a school's MIS it could enable a teacher to identify all students automatically and gain access to information such as their attendance, achievements, timetable and personal contact details.

AR has a great potential in changing the way students are taught in class across various fields in education. The technology is transforming the educational landscape. Users are supportive in the use of AR especially students as it adds more colour to the traditional education method. It gives students an up close look at objects like never before, and gives them the platform to be creative in their learning besides adding value to the learning experience.

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