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Visualizing Knowledge: A Survey on Augmented Reality's Impact on Education and Training

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Abstract— ***This paper surveys the field of augmented reality (AR), in which 3D virtual objects are integrated into a 3D real environment in real time. It describes the medical, manufacturing, visualization, path planning, entertainment, and military applications that have been explored. This paper describes the characteristics of augmented reality systems in education sector, including a detailed discussion of the tradeoffs between optical and video blending approaches in education environments. Registration and sensing errors are two of the biggest problems in building effective augmented reality systems, so this paper summarizes current efforts to overcome these problems. Future directions and areas requiring further research are discussed. This survey provides a starting point for anyone interested in researching or using augmented reality.***

Keywords— ***Augment Reality, Virtual Reality, Training, Educational Technology.***

I. INTRODUCTION

Immersing learners in the real world and interacting with them with that world mostly cannot be convenient. Although the natural world is three-dimensional, we prefer to use two-dimensional media in education which is very convenient, familiar, flexible, portable and inexpensive. [2] But it is static and does not offer dynamic content. Alternatively, computer generated three-dimensional virtual environments can be used but these scenes require high performance computer graphics which are more expensive than others. [1] Although lots of opportunities virtual worlds may present for teaching and learning, it is hard to provide an adequate level of realism. When users are completely immersed in this environment they become divorced from the real environment [3]. So, it gives you virtual things by modelling the real world you're experiencing. This study has a dual aim. Firstly, the definition of augmented reality (AR) is given about this new artificial and augmented environment. Characteristics of augmented reality systems are provided and technologies are classified used in this system. Secondly it's potential in education within this context.

II. EASE OF USE

2.1. Technologies for Augmented Reality Systems:

Technology plays an important role in AR research. In some previous studies the term "technology" is part of the definition of AR. For example, Klopfer and Sheldon (2010) defined AR as a "technology" that blends real and virtual world experience. The aforementioned restricted approach views AR as a form of virtual reality with a head-mounted display (Milgram et al., 1994). This definition reflects the early development of AR technology that usually included head-mounted apparatus to overlay virtual information onto the real world. With a rapid evolution of technology, the AR concept could be further extended because more and more hardware and software devices could be utilized to create augmented reality. For instance, the advancements of handheld computing open new opportunities for augmented reality (Martin et al., 2011; Squire & Klopfer, 2007) and create a subset of AR: mobile-AR (Feng, Duh, & Billinghurst, 2008). The mobility offered by handheld devices would leverage the authenticity of a learning environment and increase learners' interactions with others (Klopfer & Sheldon, 2010). Additionally, mobile devices make pervasive AR systems possible (Broll et al., 2008). Instead of using head-mounted displays, pervasive AR systems run on handheld computers with location-registered technology (e.g., Global Positioning System [GPS]). Pervasive or mobile-AR systems are less obtrusive with a focus on real environments. Another application of AR is the combination of mixed realities and remote laboratories (Andújar, Mejías, & Márquez, 2011). By overlaying virtual elements on remote devices, students could remotely manipulate and interact with the real as well as virtual devices. Together these AR technologies allow ubiquitous learning enhanced by computer simulations, remote laboratories, physical models, and 3D or virtual objects (Broll et al., 2008; Dunleavy et al., 2009). Then how can AR technologies be used for educational purposes? First, AR technologies help learners engage in authentic exploration in the real world, and virtual objects such as texts, videos, and pictures are supplementary elements for learners to conduct investigations of the real-world surroundings (Dede, 2009). One of the most prevalent uses of AR is to annotate existing spaces with an overlay of locationbased information (Johnson et al., 2010a). Secondly, the use of AR technologies can extend to the integration of real-world and digital learning resources. As Klopfer and Squire (2008) showed, the usage of AR enables learners to experience scientific phenomena that are not possible in the real world (e.g., chemical reactions). Liu et al. (2007) introduced several AR systems that fall into this purpose; through explorations in AR, students were able to view the virtual solar system on the classroom table or to visualize the process of photosynthesis. Moreover, Kerawalla et al. (2006) founded that AR technologies have the potential to engage learners in manipulating virtual materials from a variety of perspectives. In the study by Kaufmann, Steinbugl, Dunser, and Gluck (2005), a 3D dynamic geometry system (Construct3D) aimed at facilitating mathematics and geometry education was developed. As an AR system, Construct3D not only provided students with a real-world setting to collaborate together, but also demonstrated virtual 3D objects for students to operate, measure, and manipulate in order to understand spatial relationships [19].

AR allows flexibility in use that is attractive to education. AR technology can be utilized through a variety of mediums including desktops, mobile devices, and smartphones. The technology is portable and adaptable to a variety of scenarios. AR can be used to enhance content and instruction within the traditional classroom, supplement instruction in the special education classroom, extend content into the world outside the classroom, and be combined with other technologies to enrich their individual applications [20].

2.2 Augmented Reality in Education:

AR is likely to be a new form of demonstration where there is no need to have any physical model presented, hence it should be available for students at home (only a printed AR marker, a webcam and a computer with internet connection is required). [4] AR books, AR development and logical games are just about to appear in education. See some examples below. The use of AR-technology could be incorporated in many subjects i.e. math's lessons of geometry, or 3D representation of cells in biology, [5], in chemistry displaying molecular structure [6] or in PE a team sport simulation can be created. Additionally, any subject can be more colorful, interesting and interactive using augmentation. Furthermore, education may profit from AR development or logical games [11]. In computer science lessons students can familiarize themselves with the background of AR and they can create their own AR projects. For instance, beginners can create their own 3D pop-up books at ZooBurst. After having registered, storytellers can create their own world in which their stories can come to life. An ARmarker can be assigned to the virtual book that helps the physical book to become live. (www.zooburst.com) On a next level, students could construct a 3D model with 3D authoring tools and an ARmarker accompanied by their own AR source codes.

2.2.1 The Current Position of AR in Education and Training:

During the last few decades, many professionals and researchers have been developing pragmatic theories and applications for the adoption of AR into both academic and corporate settings. By virtue of those studies, some innovations of AR have been developed and are being used to enhance the education and training efficiency of students and employees. In addition to that, there are a great number of studies going on to improve the compatibility and applicability of AR into real life [8].

Displaying information by using virtual things that the user cannot directly detect with his own senses can enable a person to interact with the real world in ways never before possible. We can change the position, shape, and/or other graphical features of virtual objects with interaction techniques augmented reality supports. Using our fingers or motions of handheld devices such as shake and tilt we have an ability to manipulate virtual objects, as well as to physical objects in the real world. Augmented Reality can be applied for learning, entertainment, or edutainment by enhancing a user's perception of and interaction with the real world. User can move around the three-dimensional virtual image and view it from any vantage point, just like a real object. The information conveyed by the virtual objects helps users perform real-world tasks. Tangible Interface Metaphor is one of the important way to improve learning. This property enables manipulation of three-dimensional virtual objects simply by moving real cards without mouse or keyboard. Augmented Reality can also be used to enhance collaborative tasks. It is possible to develop innovative computer interfaces that merge virtual and real worlds to enhance face-to-face and remote collaboration [9].

2.2.2 How AR Works in Education and Training:

In the sector of education and training, it allows technicians, for example, to learn new procedures in real conditions. Faced with a new device, the person can discover the disassembly procedure step by step by seeing the instructions appear in real time. HoloLens for example allows medical students to manipulate and visualize the human body with unprecedented accuracy [10].

In addition, Augmented reality has also been used to help visualize anatomy, lung dynamics, and laparoscopy. For example, “Mirracle” is a system that uses a camera to mimic a mirror view of the user, but superimposes images from a CT scan giving the user a view of “their” anatomy. This determines where to show the image by creating an infrared-based depth image with a Microsoft Kinect sensor. ProMIS is an augmented reality laparoscopy simulator that uses a surgery dummy and superimposes labels and internal organs on the camera feed to both train and evaluate students [11].

The use of AR-technology could be incorporated in many subjects i.e. math's lessons of geometry, or 3D representation of cells in biology, in chemistry displaying molecular structure or in PE a team sport simulation can be created. Additionally, any subject can be more colorful, interesting and interactive using augmentation. Furthermore, education may profit from AR development or logical games. In

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2.2.3 AR in Higher Education:

Technology is currently in a moment of great development in the field of education, as a result of the continuous advances that are occurring in techno–pedagogical matters that promote its inclusion in learning spaces, where technology is increasingly attaining greater use in training activities thanks to its ubiquitous and ergonomic nature. All this has led to new student activities, not only in the way they communicate and collaborate with their teachers and peers but also in the way they interact with contents in a digital way. Educational technology has managed to stimulate the teaching and learning process by enriching interactions with information, thereby creating a benefit in the essential aspects of teaching, such as student interests, motivation, and participation. This current educational landscape has conditioned the professional practice of teachers and is visible in the need to carry out innovative practices according to the requirements of an education immersed in this digitalized era.

One of the technologies with great promise in the field of education is augmented reality (AR), which allowing for unique instructional activities to facilitate learning. Experts define this technology as an innovation that "allows the combination of digital information and physical information in real time through different technological devices", thereby promoting access to expanded information about us through mobile devices. The literature shows that AR is a resource that can be used in different educational stages, from the initial stages of school to higher education.

Likewise, AR offers a series of potential benefits in the learning process, such as the assumption of a greater role for the student, an increase in the student's motivation, self-regulation, and interest in a task, and the exploration of teaching materials and content. AR also encourages digital competition and promotes the development of significant, constructivist, collaborative discovery, and ubiquitous learning. These benefits favor both the improvement of teaching results and the environment of training spaces [13].

AR is a very efficient technology for both higher educations' such as universities and colleges. Students in both schools can improve their knowledge and skills, especially on complex theories or mechanisms of systems or machinery.

2.2.4 The Application of AR in Different Subjects:

Augmented astronomy: In an astronomy class, students learn about the relationship between the earth and the sun. For the sake of students' understanding, educators may employ AR technology with 3D rendered earth and sun shapes.

Augmented chemistry. Augmented chemistry is an interactive educational workbench that can show students how and what an atom or a molecule consists of via AR. Three elements, a booklet, a gripper, and a cube, are required to implement this task with both hands. Fjeld & Voegtli (2002) said that the booklet displays components by a printed picture and a name. One hand browses the booklet with a gripper that has a button used to connect an atom to the molecular model. According to Fjeld & Voegtli (2002), users first bring the gripper around the element in the booklet and get information about the element by clicking the button of the gripper. Users then move the gripper next to a cube, called a platform, which holds a molecule. Subsequently, by rotating a cube operated by the other hand, users can determine where and how the element connects to the molecule.

(a) (b) (c)

Figure1. a) Booklet offering one element per page – here Na – sodium. Each element is represented by a pattern. b) Gripper with a button (red) and a pattern. c) Cube with one distinct pattern for each surface

Augmented biology. AR can be used to study the anatomy and structure of the body in biology. he Specialist Schools and Academies Trust (SSAT) demonstrated that teachers could use AR technology to show what organs of human beings consist of and how they look by watching 3D computer-generated models in the real classrooms.

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Moreover, students may be able to study humans' organs independently with their camera-embedded laptops and AR markers that connect PCs with AR information about biological structures of the human body (Retrieved from https://www.ssatrust.org.uk/achievement/future/Pages/AugmentedReality.aspx).

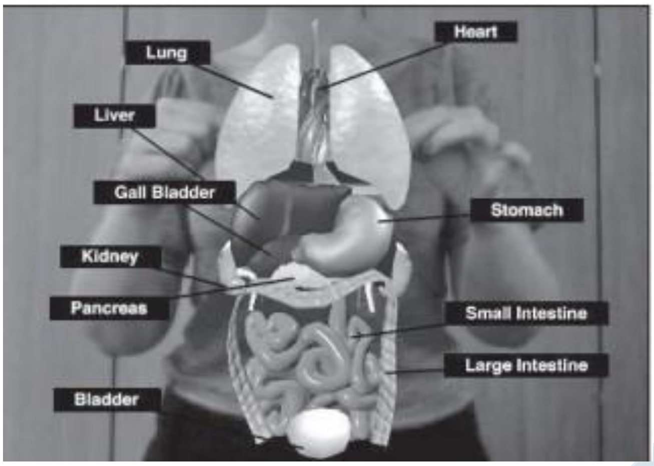

Figure 2. A model of human beings' internal organs with AR technology that can be used in Biology class

Mathematics and geometry education. With AR technology, teachers and students can collaborate by interacting with each other for some issues on shapes or arrangements. According to Chang, Morreale, & Medicherla (2010), an AR application, called Construct3D, especially was designed for mathematics and geometry education with three-dimensional geometric construction models (as cited in Kaufmann, 2006; Kaufmann & Schmalstieg, 2002; Kaufmann, Schmalstieg, & Wagner, 2000). This application allows multiple users, such as teachers and students, to share a virtual space collaboratively to construct geometric shapes by wearing head mounted displays that enable users to overlay computer-generated images onto the real world. Furthermore, Kaufmann (2009) determined that AR can be used in dynamic differential geometry education in a wide range of ways. For instance, using the AR application, teachers and students can intuitively explore properties of interesting curves, surfaces, and other geometric shapes

Physics education. Physics is another area where AR can also be used to demonstrate various kinematics properties. Duarte, Cardoso, and Lamounier Jr. (2005) evaluated AR to dynamically present an object that varies in time, such as velocity and acceleration. he real and estimated experimental results can be visualized by using AR techniques that are more interesting than existing learning methods, and thus improve learning. The research by Chae & Ko (2008) demonstrated that physics simulation is added to objects using open dynamics engine (ODE) library.

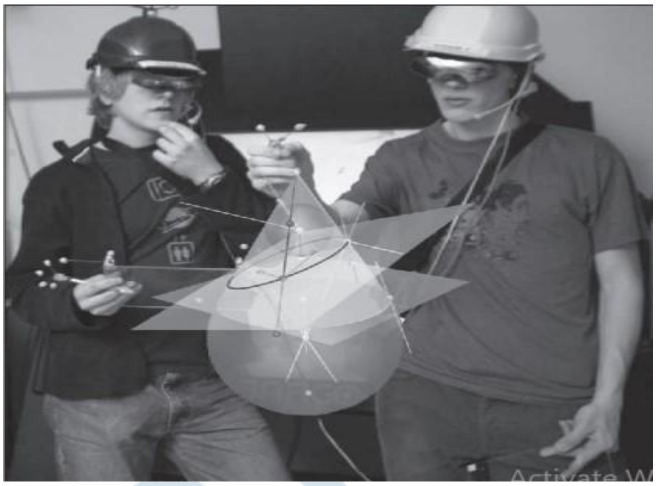

Figure 3. Students working with construct3D inscribe a sphere in a cone (Kaufmann & Schmalstieg, 2002). Image by courtesy of Hannes Kaufm1ann

2.3 Challenger of AR in education and training field:

Attention Tunneling: In a portion papers, students reportedly experienced higher attentional demands from AR system. This resulted in the student ignoring important parts of the experience, or feeling unable to properly perform team tasks [15].

Usability Difficulties: Several studies find that users report AR systems as more difficult to use than the physical or desktop-based alternatives. As reported earlier, interestingly many of these studies also find that users like the AR systems more than the alternatives [16]. A training should be provided for teachers to learn a hands–off approach with their students and show them how this way of teaching will foster an effective learning environment [18]

Learner Differences: Some studies reported that for some students, AR may not be an effective teaching strategy. In [17], the authors report that although low- and average-achiever students showed learning gains through the AR experience, high-achieving students did not. Another study indicates that students who were low-ability readers did not learn from parts of the AR experience.

III. CONCLUSION

The future of AR as a visualization technology looks bright, as shown by the interest generated in business and industrial circles as well as discussed in popular periodicals and research papers in the education and training fields. Many questions still linger in terms of efficiency and when compared to traditional methods, particularly given the investments needed in research and design. However, there is much optimism of AR in education and training for the future. New technologies and information communications are not only powerful and compact enough to deliver AR experiences via personal computers and mobile devices but also well developed and sophisticated to combine real world with augmented information in interactively seamless ways.

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