Augmented Reality Application in Laboratories and Learning Procedures

Anasse Hanafi(✉), Lotfi Elaachak(✉), and Mohamed Bouhorma(✉)

LIST Laboratory, UAE University, P.O. Box 416, Agadir, Morocco
anasse.hanafi94@gmail.com, lotfi1002@gmail.com,
bouhorma@gmail.com

Abstract. It is commonly said that Augmented Reality opens new perspectives for training. Today, it is unlikely that the audit objectives will be met. One of the major criticisms of traditional computing is that the digital world of the computer is too disconnected from the real world in which users evolve. Mixed Reality (RM) focuses on interactive systems in which real objects and computer data are coherently merged. However, integrating these new tools into the existing learning processes remains complex, due to the technological aspects and the data continuum to be implemented, through the identification of use cases and the associated gains and by the diversity actors and experts to involve in this process: the expert of the main field, the designer and the IT developer. In this paper we aim to develop an augmented reality application by following a developing process that will led to the planned results. The proposed application will be dictated for learners in higher education context, especially newbies that will practice their first experiment in the laboratory e.g. "biology, chemistry" by giving them an interactive environment to understand the safety procedure followed during experiments in laboratories.

Keywords: Augmented reality · Mixed reality · Technology · IT · Learning processes · Training

1 Introduction

IT environments for human learning are articulation of work in the complex and technologies learning. Using augmented reality in education can influence students to acquire actively and can encourage them, leading to an operative procedure of knowledge. Previous research has detected the problematic that technology will create an unreceptive learning procedure if the technology used does not involve critical thinking, meaning making or metacognition. Since its introduction, augmented reality has been shown to have good possibilities in making the learning procedure more dynamic, expressive, effective and meaningful. This is because its advanced technology allows users to interact with virtual and real-time applications and brings the natural experiences to the user. Furthermore, the merging of augmented reality with education has newly attracted research attention for the reason of its ability to permit apprentices to be immersed in realistic experiences. Hence, this concept paper reviews the research that has been conducted on AR. The review calls the application of AR in several fields

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of education including Physics, Mathematics, Chemistry, Medicine, Biology, Geography, Astronomy and History.

In this perspective of research this manuscript aims to present an augmented reality application applied in the field of safe laboratory practices in order to give newbies the right procedure followed in any laboratory experience that guarantee a safe manipulation. The document will be structured as below: The related work part that discuss the application of augmented reality in education field with a comparative study concerning the realizations already exist in the literature, the second part contains the steps and process followed to establish the proposed application, then the results and discussion part with a detailed discussion concerning the pros and cons of such application.

2 Related Work

2.1 Augmented Reality in Education

Education has become surrounded by technology and the results show a confident effect on learning and training styles. According to [1], lessons/trainings that are maintained by technology will lead to more innovative methods of knowledge and learning. This is because the use of technology contains real-world difficulties, current informational resources, simulations of concepts and ideas, and communication with experts in the field. In addition, learning using technology is believed to complement the traditional ways of learning and teaching [2].

The combination of technology tools with the program of study is becoming a piece of good teaching [3]. Educators not only have to run through a good deal of personal time working with technology but also should have a high level of innovation and self-confidence to use recent technologies that are embedded in today's education system. The integration of new technology also provides a means to improve student learning and engagement in university magistral courses. Therefore, current studies have intended to better comprehend the applications adapted during lectures from the perception of learners, together with multimedia, animations, computer-based simulations, and statistical software [4]. Research by Geer and Sweeney [5] exposed that the use of a diversity of media applications to explicate ideas improve the understanding and support greater teamwork between learners.

Scholars usually find Science Discipline to be immaterial and abstract, necessitating a deepness of understanding and imagining skills [6]. When Scholars have complicated difficulties in understanding the concept or the idea well, it leads to misunderstandings. According to [7], misunderstandings between students must be considered since it can affect with the students' learning of scientific principles and notions. Consequently, the choice of teaching process or ways plays a significant aspect in avoiding or reducing the students' misunderstandings [7]. Visualization technologies (augmented reality applications) have exciting probable, for making understanding concepts easier and avoiding misunderstandings in the scientific field [8]. Kozhevnikov and Thornton [9] found that is possible to improve students' visualization skills by offering a diversity of abstract visualized images and permitting learners to manipulate and explore the images. A wide range of available technologies can be used for the visualization of abstract notions and concepts. Examples of visualization technologies that have been inspected in preceding research include virtual environments, and animation. [10] propose that scholars can expand their mastery of abstract notions using augmented reality applications that have been designed for education.

Scientific notions can be characterized as theoretical notions or ideas. An example of expressive notions can be found in Biology such as food chains. Theoretical notions imitate notions that cannot be perceived with eyes, such as, photosynthesis or air pressure (colliding molecules). Recent studies have confirmed the advantageous usage of technology in visualizing immaterial notions. These technologies offer an income for making observable phenomena that are too large, small, fast or slow to see with the single-handed eye [11]. For example, [12] developed an animation to assist scholars comprehend the abstract notions in Chemistry. Regarding the authors, this kind of technology permits scholars to perceives the exchanges between molecules and to comprehend the related chemical concepts. [13] used software to generate a simulation of enzyme-substrate binding for instruction cell biology. The use of AR technologies such as these in teaching is becoming more advanced and classier.

Today, one of the technologies that shows excessive possibilities in teaching especially in visualizing abstract concepts and notions is AR. Rendering to [14], augmented reality is a new technology that is expected to influence teaching. This entitlement is maintained by the Horizon Reports between 2004 and 2010 which define AR as a technology that transports the computer world to the human world [15].

AR is different from virtual reality because AR augment real world using virtual objects, while virtual reality immerses users in a completely virtual world. AR is a new technique to make better the study of three-dimensional figures as an alternative of the old-style method in which educators use wooden stuffs. According to [16] there are numerous benefits of using AR applications for learning purposes. For example, AR can reduce the misunderstanding that occur because of to the incapability of scholars to visualize concepts and notions such as chemical bonds, because AR permits full visualization and object animation. AR also has the benefit of permitting macro or micro visualization of objects, notions and concepts, that cannot be visualized with naked eyes. Augmented reality application shows objects in different ways and with different viewpoints which aids the learners to better comprehension.

Augmented reality technology can be used as a powerful visualization tool that offers scholars opportunity to study by interacting with virtual objects in 3D environment [17]. Different than virtual reality, AR does not essentially need specific equipment like (HMD - head mounted displays). Every year, the processing power of smartphone is increasing, thus, more and more smartphones have the capability to user AR detection. E.g., in 2016 Lenovo launched PHAB 2 Pro. The first device ever to support Tango Project developed by Google and that support depth tracking [18].

Looking deeper into AR application, those applications can be divided into two categories. First one contains applications with the capability of scanning real object (target). While Second one, includes applications or platforms that have their own authoring tools which allows users to generate their own AR content. Aurasma platforms is an example of the second category. Founded in 2011, Aurasma, the world's leading AR platforms, a powerful drag-and-drop web studio that enables anyone to easily create, manage, and track augmented reality campaigns [19].

Studies demonstrate that game-based learning has been recognized as an advantageous way to make better education by making it more amusing and attractive. According to Prensky, games joining educational objectives with teaching aids can potentially make the learning of academic subjects more learner-centered, easier, more motivating, more pleasurable and therefore more effective [24].

Instead of using traditional teaching methods, scholars can figure out by themselves just by processing activity the information. Completion of tasks in the game better meets the needs of the contemporary work environment where the processing and analysis of information is important [25].

It is important to encourage education and the attainment of new skills for the upcoming. In 2016, the World Economic Forum presented research that known that there is a gap between the skills people gain and the skills they need, and that it grows even bigger. Traditional learning no longer offers scholars the necessary knowledge in their upcoming careers. Consequently, there was a collection of 16 skills resulting - scholars require them in the 21st century to be competitive, See Fig. 1. [26].

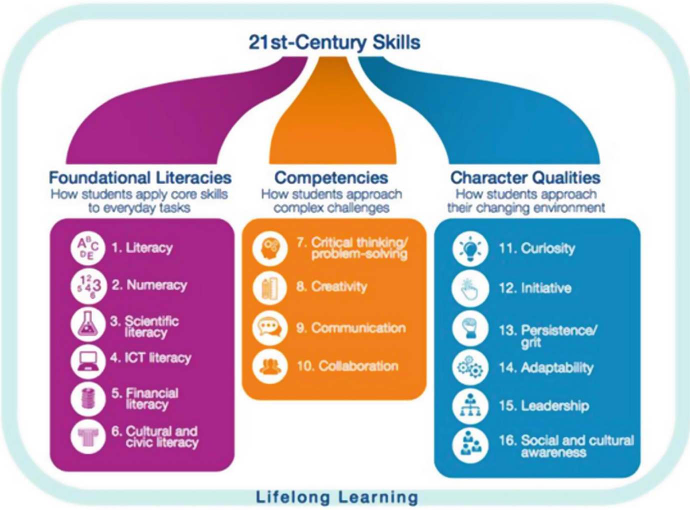

Fig. 1. 21st century skills.

One way to foster this skills collection is to integrate game-based learning in which augmented reality can play an enough role.

To demonstrate this, [19] presented a case of using augmented reality for schooling astronomy in a 3-dimensional way. The study, which includes AR projection on the whiteboard and a traditional training session using 3D physical models, exposed that educators comprehended the profits of using 3D and recognized that AR can make unreachable subject material accessible by scholars. The restriction of this study was the lack of evidence that AR was no doubt more advantageous than the actual 3D models “AR can deliver representation of otherwise invisible concepts, events and notion or those that are hard to perceive”.

The idea of localized learning is a concept that describes the learning process as social, combined with scholar's life. The mobile AR system could offer localized learning improved by computer simulations, models, games and virtual objects in real-world. In case of "Environmental Detectives" described by Klopfer scholars, learning using handheld computers out of classroom to conduct investigations and data collection for exact location, analyzed them, and suggested solutions [28].

2.2 Augmented Reality in Laboratories

Augmented Reality is an emerging form of experience in which the Real World (RW) is enhanced by computer-generated content tied to specific locations and/or activities. Over the last several years, AR applications have become portable and widely available on mobile devices. AR is becoming visible in our audio-visual media (e.g., news, entertainment, sports) and is beginning to enter other aspects of our lives (e.g., e-commerce, travel, marketing) in tangible and exciting ways. Facilitating ubiquitous learning, AR will give learners instant access to location-specific information compiled and provided by numerous sources (2009). Both the 2010 and 2011 Horizon Reports predict that AR will soon see widespread use on US college campuses.

Layar (Netherlands-based company) found in 2009, proposes augmented reality browsers and interactive print tools for mobile devices. Teachers typically use Layar to augment posters on different subject. Scholars aged between 9 and 10 years, hand-crafted posters illustrating the functions of the human body structures. They used Layar creator to enhance digital assets to physical posters and it assisted them to comprehend the fundamentals of biology [20].

A French company called 'Augment' provides a complete solution for configuring, managing and observing 3D content in augmented reality. It has a free license for educational purpose. Using 'Augment' and tools for modelling 3D creation to create a detailed historical tour in ancient Rome for the students to explore eternal city. It permits a dynamic engagement with the site during field trips rather than just watching the lecture slides [21].

Latvian Anatomy Next is very helpful for medical scholars as it covers extremely exact 3D anatomy models that can be envisioned with AR and, what is important, are authorized and validated by the academics in medical field. The authors claim that the models can be used to support the curriculum and improve scholars' skills in three-dimensional visualization of structural associations. This application can be used as an early phase to train medical students to gain more knowledge about surgical procedures [22].

MoleQL is an AR application used to learning and study chemistry concepts and notions. It assists scholars overcome the difficulty of studying science by visualizing chemical elements and providing general information about their application in the environment. Target objects can be digitized separately or combined to form chemical reactions, while being safer and more economical for educational establishments. The solution has received a lot of feedback from professors and scholars [23].

Above listed AR application list in the field of education is far from complete, but it suggests that augmented reality brings learning to life and makes it much easier and more attractive than the existing learning system. The biggest challenge for educators could be the creation of 3D content in case they want to use totally new models, as this requires quite advanced knowledge.

Teaching and learning science are a complex stuff and Its level of abstraction is very high. It is therefore necessary to confirm the effective use of educational resources and to make the choice of additional tools as effective as possible. Chemistry necessitates acquaintance and understanding of an exact complex vocabulary. It sounds and is written not as something kids have come upon before. Gaming method can support to seamlessly progress this crucial skill.

As mentioned by Gee, kids grow huge vocabularies while playing Pokémon (not even an augmented reality game). There are so absorbed by the gaming experience that after a while turn out to be the specialists of this language and make themselves for exploit in the fields in which the expert language is used. Kids construct new knowledge built on the knowledges they have had already in order to comprehend new things a classical clarification for the constructivist learning theory [29].

The same exact idea can be used in teaching, especially for learning sciences and is scholar built their acquaintance with familiar analogies, the procedure of building acquaintance is much more effective. MoleQL is being developed by Estonian company Subatomic OÜ with this thought in mind: the use of AR should be benefitted to transport familiar context into learning, both physical and cognitive.

The operating principles of MoleQL are simple. Initially, the user needs to install the mobile application on a handheld device – a smartphone or a tablet. The operating principles of Mole QL are simple. First thing to do, is to install the application a smartphone or tablet device (handheld device), then, print out the cards which represents chemical elements, and lastly scan printed cards with the camera of the device, and the application will render 3D object of the correspondent chemical substances on top of the card within user's natural environment. The main benefit of this application is the possibility of combining multiple card, or modify some conditions like the temperature, it will help the user to see how certain chemical reaction occurs.

With the purpose to investigate the effect (impact) of the augmented reality application in education on learners, a collection of 20 participants of first year electrical engineering scholars, was chosen to perform the trainings using AR application. 10 of them used the computer's screen to visualize the computer-generated 3D objects while the others used HMD. They were invited to execute following operation on electrical machines assisted by instructions given by the AR application, next day we asked them to perform the same operations without using the AR application to verify the achievement, scholars have been able to work on them without the help from the teacher who does not even need to interact with them, seeing that the processes are successful. The results show the scholars who were able to complete the process in the two sessions offered (Table 1).

Table 1. Session of the training for scholar.

Heading level	Day 1 Using the AR app	Day 2 Without the use of AR app
Using PC	9	8
Using a head mounted display	10	10

A satisfaction survey demonstrate that all scholars expressed a very confident and optimistic attitude on the way of augmented reality technology and increased content. They felt that the AR application used is strongly organized. The overall assessment of the training was brilliant, and most scholars found it very beneficial, very exciting and gratified with the technology and methodology. All the scholars considered that the RA system was agreeable to use in education [31].

3 Method

3.1 Working Methodology

Mixing is the essential component of an augmented reality system; it consists of the integration (from a visual point of view) between the real world and the virtual world. The goal is to keep the virtual objects (often 3D graphic elements) aligned with the physical objects of the real world in the visualization of the user: it is the registration. To achieve this alignment correctly and consistently, the system must determine the position and orientation of the user as well as objects in the environment: Tracking. Thus, tracking and registration can be defined as one of the fundamental problems of augmented reality [32].

3.1.1 Tracking

Accurate, fast and robust tracking of the user and objects in the environment and a determining element in any augmented reality application. We present and discuss below the different existing approaches to the monitoring process:

1. Tracking based on sensors:

It is to use sensors to determine the position of the user in the environment, there are several types of sensors: magnetic, acoustic, inertial, accelerometers, compass, GPS, … Two types of monitoring can be distinguished [33]: outside-in monitoring and inside-out monitoring. The first type (outside-in) refers to systems that fix sensors in the environment to track transmitters placed on moving targets. The second type, (inside-out), uses sensors attached to moving objects that are able to determine their position relative to transmitters set in the environment.

Those methodologies have the advantage of being robust to abrupt movements, but they have also the inconvenient of being sensitive of environment perturbation.

2. Visual tracking

Thanks to advances in the field of computer vision, so-called visual tracking approaches based on position detection by cameras have become very popular.

A first approach of tracking said markers uses easily recognizable patterns [34] whose major advantage is that they are not excessive in terms of computing power because the analysis of a single image can detect the position of markers. Figure 2 shows some examples of markers used.

Fig. 2. Examples of markers

Another "markerless" visual tracking approach is to calculate the position and orientation of the camera based on the size and deformation of a known object identified by image analysis [35]. This approach requires that at least one object of enough size be present in the field of view of the camera. Formally, to determine the position and the orientation of the camera is translated into the determination of the projection matrix which makes it possible to obtain the 2D image (of the camera) starting from the 3D form of the object (known beforehand). Visual tracking systems without artificial markers are still the most difficult to implement but also the most promising for future applications of augmented reality.

3. Hybrid approaches

In the absence of an optimal solution, the current trend is to use hybrid tracking approaches in which a vision-based approach is coupled with capture-based assistance [36].

3.1.2 Alignment

One of the most important issues in augmented reality applications is virtual/real alignment. The objects in the virtual world must be superimposed correctly on the real objects, so that the user has the impression that the two real and virtual worlds coexist together.

Alignment errors are difficult to control and are one of the main barriers to Azuma [37] defines two types of errors: static and dynamic. The static error appears when the user's point of view and the object in the world remain fixed. Dynamic error occurs when the user's or object's point of view is moving in the environment.

In current systems, dynamic errors are usually the primary source of misalignment.

1. Spatial Alignment: Static Errors:

The static error is defined by the alignment error between real object and virtual object, determined when the user is in a static position. According to Holloway [38], we can distinguish three types of static errors that are defined as follows:

- optical distortion
- the error of the tracking system,
- and the poor estimation of the parameters (field of view, distance eye/sensor, inter-pupillary distance, etc.).

Optical distortion is a well-known problem that is due to the properties of the lenses of the cameras. The tracking system error is generated by electromagnetic sensors sensitive to magnetic field distortion. The poor estimation of the parameters is the most studied error in augmented reality. A reliable estimate requires robust methods based on a definition of constraints in the calibration procedure. From a modeling of the system, we are interested in the calibration of these different parts. We can then use automatic methods (by vision, self-calibration) or user-based methods (simple and effective methods).

2. Time Alignment: Latency

The dynamic registration of computer images on the real world is a crucial step in the development of an augmented reality system. Data from different acquisition systems, such as image tracking and image tracking devices, must be recorded spatially and temporally with the user's point of view. Each device induces a delay associated with the observation of the world and the display on the display system. The difference in delays between the various acquisition devices or processing systems is called relative latency. It represents a source of misregistration and must be reduced. Delay sources are classified into six categories and are represented by: data arrival delay, processing delay, rendering delay, display delay, synchronization delay, and update delay.

4 Conclusion

Augmented reality is a recent technology that has appeared with potential for application in education. While numerous studies have been led on AR, few researches have been led in the education field. The number of researches on augmented reality is increasing due to the efficiency of this new technology in last years. AR has been used in different fields in education.

Despite these promising results, question of the additional value of augmented reality remains. More comprehensive, differed and longitudinal user testing would allow to make the conclusions on user engagement and the effect from using augmented reality on the academic performance.

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