Use of Augmented Reality in terms of creativity in School learning

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Abstract. Education provides a plethora of tools that can be used (alone or combined) for achieving better results. One of the most recent technological advances that can be used as an educational tool is Augmented Reality, a technology that can combine virtual and physical objects in order to enhance the real world. However, little is known about this technology and its possible applications in primary and secondary education. This paper consists a literature review focused on AR and its current and future incorporation in modern education via various context aware technologies (e.g. tablets, smartphones) which can provide opportunities for more interactive and joyful educational experiences. Also, it is described the possibility of implementing AR in Open Course Project situations, such as the one which is available at the Eastern Macedonia and Thrace Institute of Technology. Its purpose is to inform "creators" and stimulate "users" so that the benefits of this promising technology may be diffused throughout the educational process.

1 Introduction

Education of the 21st century can provide a wide variety of tools that lead towards the achievement of better results. Traditional teaching methods, such as face-to-face instructions, along with some socio-cultural beliefs jointly shape an educational procedure where everything is controlled by the teacher (Nincarean, Alia, Halim, & Rahman, 2013). These educational systems are often described as monotonous, since they do not offer many possibilities for enhancing students' creativity (Tomi & Rambli, 2013).

One of the most recent technological advances that could be used as creativity promoting educational tool is Augmented Reality (AR), a technology that enables users to see and experience the real world mixed with various virtual objects, without losing the sense of reality (Cuendet, Bonnard & Dillenbourg, 2013; Fonseca, Martí, Redondo, & Sánchez, 2014). AR can accord a great potential for engaging, motivating and supporting the creativity of students in a restricted school environment, in ways that otherwise it could not be possible (Kerawalla, Luckin, & Woolard, 2006).

This transformation of learning with technology as a cognitive tool, according to researchers can increase the level of participation, understanding and learning, three

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key elements of all educational systems' targets (Nincarean et al., 2013). Provided that the Information Technology (IT) tools have already been implemented in school class, the incorporation of AR in education is something that can be accomplished easier, as students are familiar with handling IT devices (Chiu & DeJaegher, 2015).

In this paper we present the basic characteristics of AR, the most used AR technologies and AR's incorporation, current and possibilities for future, in education. Also there is an example of AR's educational application that our team constructed. Finally, it must be mentioned that AR, as an educational tool, is being approached under the belief that learning has a strong social nature and the inclusion into human activity of a tool that affects this activity by transforming it, should be treated as something that influences both teams and individuals (Kerawalla et al., 2006).

2 Augmented Reality

The first and basic step for someone in order to follow any science path is the determination of the object under study. Many definitions may be given for Augmented Reality (AR), but the current study will use the following as the more representative (Cuendet et al., 2013):

"Augmented reality refers to technologies that project digital materials onto real world objects. This definition suits a large spectrum of technologies that range from a pure virtual environment to the real environment."

It must be mentioned though that AR applications and systems should have most or all of the above properties (Roesner, Denning, Newell, Kohno, & Calo, 2014):

- *Sense properties about the real world.*
- *Process in real time.*
- *Output information to the user, including via visual, audio, and haptic means, often overlaid on the user's perception of the real world.*
- *Provide contextual information.*
- *Recognize and track real-world objects.*
- *Be mobile or wearable.*

Another important fact related to AR is its origin, as it is considered to be the evolution of Virtual Reality (VR). It could be pointed that the basic difference between VR and AR is the fact that VR does not use at all the camera field, something that AR is based on (Sood, 2012). It would be really useful for the reader the presentation of a schematic classification from Real Environment (RE) to Virtual Environment (VE) in order for him to see the exact position of AR at the Reality-Virtuality Continuum (Salmi, Kaasinen, & Kallunki, 2012). As it can be seen, AR is in the middle of the two edges, which means that it combines the RE with the VE, but it is closer to reality.

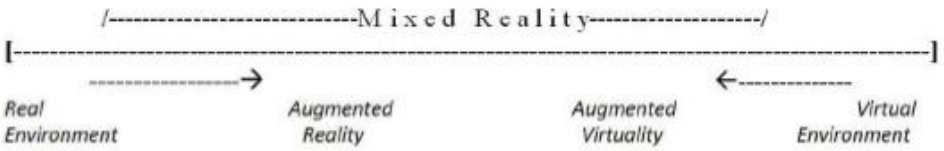

Fig. 1. Figure 1: The Reality-Virtuality Continuum (Salmi et al., 2012).

2.1 Technologies for Augmented Reality

Like every technology, AR needs some devices (hardware technologies) for its application. These devices usually are displays, computes, tracking and input devices. Two of the most common AR systems are: Head Mounted Displays (HMD) and Handheld Displays (Kesim & Ozarslan, 2012).

- *Head Mounted Displays (HMD)*

HMDs are displays that are applied on users' heads and their structure can be compared to this of a helmet. A typical HMD is comprised of one or two small displays that are bonded on a helmet or eyeglasses. They can display computer generated images or a combination of the real world enhanced with these images. They are usually applied in military, engineering and gaming situations. Due to their high cost they are not preferred for educational purposes (Kesim & Ozarslan, 2012; Rolland & Fuchs, 2000). Some basic examples are the Google cardboard, Google glass, Microsoft Hololens etc.

- *Handheld Displays*

Handheld displays are small devices with computer software that a user can handle them with his hands. They can overlay graphical context onto an image from the real world. The most common and easy to use handheld displays are smartphones and tablets. Their greatest advantage is their portability, their significant low cost and their ease of operation. On the other hand users have to constantly hold them in front of them in order to have access to AR content. A handheld device, in order to be suitable for AR applications should have a camera, GPS, digital compass and marker systems. Their advantages render them as the most popular devices for educational applications (Kesim & Ozarslan, 2012; Wagner & Schmalstieg, 2006).

3 Augmented Reality in Education

Since AR is considered to be a relatively new technology, its incorporation in education is in a quite embryonic stage. It was only until 2000 when the first thoughts of applying such a technology started to make their appearance. Sheldon and Hedley explored AR's application in undergraduate education and concluded that it was useful especially for teaching courses that students could not fully understand and experience due to the limitations of the real world (Kerawalla et al., 2006). After this, the way for

further more experimentation on incorporating AR in education was opened. Soon primary, secondary education and higher education institutions started applying experimentally AR in order to conclude whether it is really going to help students.

3.1 Current situation

Augmented Reality is available for educators in two different forms, location-aware and vision-based AR. With the location-aware type AR users, via a GPS supporting device, are able to have access to digital media as they move around to the physical world. On the other hand with vision-based type AR a device with a build-in camera can be used for presenting AR content, but only after user has pointed the device at an object that has been linked with digital material. These two forms of AR have been proven a significant helpful tool for educators in their effort to create a more stimulating and creative environment for students (Dunleavy & Dede, 2014). The above mentioned have led to the hesitant but increasing use of AR from educators all around the world and also the ever growing number of researches related to its extensive use in future years. In the next paragraphs, some research examples of AR in different stages of education will be presented.

In 2005 a team of researchers conducted a study in London, UK, for the potential of AR for teaching primary school science in ten year old children. Teachers and children were provided with an animated virtual representation of a spinning earth and a sun that they could rotate to aid understanding of the relationship between sunlight and night and day. Results showed that children taught with this system were less engaged than others that were taught with the traditional methods, teachers that used AR were more likely to ask children to watch an AR animation and describe it and finally teachers recognized the potential of AR technology but they would like it to be more flexible and controllable (Kerawalla et al., 2006).

Also, in 2011 A. Di Serion, M.B. Ibáñez and C.D. Kloos studied the effects of AR on the motivation of students on a visual art course at a middle school in Madrid, Spain. The presented material was relevant to the Italian Renaissance Art and it consisted of images and information of this period's paintings. The experiment included two situations, one with traditional teaching material (e.g. slides) and one with AR material. Results led to the conclusions that though AR is not mature enough for broad application in education the acceptance and enthusiasm of the participants showed that it can be an extremely helpful tool in the next few years (Di Serio, Ibáñez, & Kloos, 2013).

One of the most fruitful years of researches related to the incorporation of AR in education was 2013. A. B. Tomi and D. R. A. Rambli presented the development of a mobile AR application for preschool children related to the teaching of numbers with the use of an old story, *The Thirsty Crow*. The classic book was enhanced by augmenting virtual object like 3D images and sounds, via the use of a mobile device. The experiment showed that the use of AR content turned the whole procedure into a more joyful, creative and interactive learning experience and they unreservedly support the use of such technology in the educational procedure (Tomi & Rambli, 2013). Another AR tool that has been tested, in 2013, was related to teaching chemistry at a junior high

school in Shenzhen of China. Students were able to control, combine and interact with a 3D model of micro-particles with the use of markers and also they were able to conduct a series of inquiry-based experiments. Researchers concluded that the AR tool had a significant supplemental learning effect as a computer-assisted learning tool, the AR tool was more effective for low-achieving students, students presented positive attitudes towards AR and that these attitudes were linked to their evaluation of the software.

Finally, a team from Spain studied the possibility of teaching human history with AR in 2014. The whole approach was called REENACT and is based on the exploitation of AR for improving the understanding of several historical events. Results were evaluated as "extremely good" since the participants were able to recall and most important understand more aspects of events like the Battle of Thermopylae. AR provided new experiences that could be generalized in all school courses (Blanco-Fernández et al., 2014).

Above from researches, several AR platforms have been developed in order to facilitate the creation of AR applications. One of the most popular platform is ARlearn. ARlearn was created from the Open University of Netherlands as an AR tool for educators and learners. It supports mobile serious games and can be used for many projects, e.g. organization of a school trip or for the creation of a simple logic game for mobile phones. It is open and free but can only be used from Android devices. Also, with the use of the web based authoring tool someone is enabled to create his own games. As a platform, ARlearn, can support two types of games, games with messages in a list view and view map games. It provides four types of media objects (video, sound, narrative and multiple choice questions), map based positioning of media objects, a notification framework and the ability to download games to PC in order to be reused (Classroomaid, 2013; Open_University_of_Netherlands). Several projects have been made where ARlearn was used as an education tool. Some of these projects are: The *ELENA* project and *"Elena goes shopping"* mobile game for e-learning of languages from young children (4-6 years old) and the *"Emurgency"* program for decision and behavior training for cardiac arrest. (Classroomaid, 2013)

3.2 Future incorporation

Based on the results of researchers related to AR in education and on the fact that most of them agree that when using AR there are significant benefits for students, there are some actions that could be taken for incorporating AR into the modern educational systems (Steve Chi-Yin Yuen, Gallayanee Yaoyuneyong, & Johnson, 2011). These actions can result to the maximum augmentation of both learning and teaching environments, something that has great effects over children's creativity and future academic career (Billinghurst, 2002).

- Use of AR books

AR books can be used even from the primary level of education. They can provide a really good way of combining the physical with the digital world, since they can present interesting digital material (e.g. 3D images and sounds) as an enhancement

of the traditional book. Users can create connections with books that may encourage their imagination, creativity and occupation with reading. They are also a cheap way of presenting AR in classroom as there is no need for changes on the school book. In this way students, with the use of a simple handheld display device, can experience knowledge in a more interactive and joyful way (Tomi & Rambli, 2013).

- Use of AR Gaming

One of the most common teaching approaches in primary and secondary education is learning via games. Games have the ability to promote children's collaboration, creativity and imagination but also provide a great source of acquiring knowledge (Moschini, 2008). With the use of AR simple games can be transformed into richer and more appealing for all kind of students. With the use of markers traditional game board games can come alive via digital content and can be used for all kinds of courses, e.g. History, Archaeology, Geography and Art. Another approach is that of virtual environments where students can create their avatars and participate in online games that may have a link with the physical world (use of GPS and location-based AR) (Blanco-Fernández et al., 2014; Steve Chi-Yin Yuen et al., 2011).

- Use for modeling of objects

Another innovative way for inserting AR in classroom is modeling objects. This way allows students to visualize exactly how an item appears and also helps to overcome the boundaries and limitations of a class. Teachers, via AR, can familiarize their students with unknown situations and help them explore the most remote corners of the universe and the most inaccessible depths of the oceans (Chiu et al., 2015).

- Use for discovery learning

An educational approach of learning that stimulates students is the discovery learning. Students get to explore the outdoor environment and get in touch with knowledge at its source. But this way of teaching is not always convenient since it can be really expensive and time consuming. AR applications that provide virtual tours of different places are very easily to be found (Chen, 2014). These applications can be used in class and provide a quick, cheap and easy way to access of letting students interact with the external environment (Steve Chi-Yin Yuen et al., 2011).

- Use at Open Course Projects

One of the most current trends in education is lifelong learning and especially through Open Courses, which enable learners to broaden their research scope according to their interests. This way of teaching may give to its participants "new insights into their fields as well as make the teaching process more rewarding". Also, it can provide the ability to achieve a better level of engaging students with the academic process. AR, as an innovative technology, can boost the performance

of these courses, since it is an easy, cheap and extremely interactive way of enriching the curriculum of various Open Course Projects (Dave Cormier & Siemens, 2010).

The Eastern Macedonia and Thrace Institute of Technology (EMATTECH) participates to the National Open Academic Courses initiative (GUnet, 2015) by contributing a large number of subjects taught at the various departments of the institution. The developed courses are distinguished into three categories (A-, A, A+).

- A- Courses: This category provides a description, objectives, keywords, notes and presentation slides, literature and other educational materials, organized into topics.
- A Courses: They contain materials found in A- Courses and additionally include podcasts, synchronized with presentation slides.
- A+ Courses: They provide what has already been reported in previous course categories and in addition they include video-lectures.

As all courses of all categories contain learning material in electronic form, the first step is to acquire this material and upload it to the institutional distance learning platform. The platform that was selected for this purpose at the Eastern Macedonia and Thrace Technological Institute is Moodle. The electronic material can be lecture notes, presentations, exercises or any other material that the lectures wish to be included. As soon as the material for a particular course is received, a corresponding distance learning course is created in Moodle, and the learning material is organized in sections according to the lecturer's requirements. In addition to educational material the electronic form, A+ category also include videos of lectures in high-quality digital form. Recordings of lectures can take place either during the actual lecture delivery to students with the use of portable equipment, or at a time of the lecturer's choice, using a room equipped with a static camera. As soon as a lecture is completed, the resulting video is stored on an FTP server, where it can be accessed at a later time for video editing. When the video lectures are prepared (i.e. processed, edited and converted to an appropriate format), they have to be uploaded to the OpenDelos platform (GUnet, 2015).

AR could be used as an educational tool for improving the results of EMATTECH's Open Course Project, via open source AR software such as Aurasma, ARToolKit, Junaio or Wikitude. The addition of AR components in the output of Open Course project will result to the enhancement of learning content and of the learning process, as the learner should be also able to interact with the video and other leaning material rather than simple download and access it.

The abovementioned ways of incorporating AR in future educational settings provide easy to apply ways that do not consist a financial burden for a country's educational system.

4 Conclusions

As Information Technologies are becoming a part of modern educational systems (European_Commission, 2014; European_Union, 2013) teachers and educators try to find joyful and efficient ways of incorporating them in their classes. AR is one of the most promising technologies for educational applications, and this is why researchers all around the world are experimenting on how its application could reach its full potential on students' progress. Its capability to combine the real world with virtual content presents new possibilities for learning and enhances the quality of the provided education.

AR has the possibility to entirely change the way that people treat education. Students can now interact with digital content that empowers their imagination, creativity and learning. Teachers can incorporate AR via various ways like AR books, AR games, modeling and discovery learning. It is essential to try and adopt technologies and techniques that will improve educational systems and by extension children's experiences.

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