Augmented Reality in On-line Education

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Abstract - **In the last decade, information and communication technologies became an inseparable part of our daily life. When it comes to education, they could be integral to achieving significant improvements in terms of productivity, student motivation and engagement. With that in mind, it is only natural that there is a significant increase in the use of the aforementioned technologies in both teaching and learning.**

For the purpose of this paper, we focused on the use of augmented reality (AR) in on-line education. First of all, we analyzed the latest trends in education technology and the potential of AR for educational purposes. After concluding the analysis, we created a representation of the Solar System in AR and evaluated the options of improving the application. Key words such as on-line education, e-learning, m-learning, gamification, AR were all fundamental building blocks of this paper.

Keywords **- on-line education, gamification, augmented reality.**

I. Educational Technology

Historically, educational technology can be traced back to the past, when early cultures invented first writing systems such as pictograms, or logograms and begin to use to them to transfer information. Since then, one can find examples of written instructions in every culture using various means. As the technology progressed, in became more and more involved and suitable to transfer information. One of the greatest technological inventions, that greatly influenced the accessibility of information, was the invention of the printing press by Johannes Gutenberg. The shift from transcribing the books by hand or using wooden blocks, which was both painstakingly slow and laborious process and thus made the books really expensive, to being able to print them faster and cheaper was one of the first examples of how technology can change and influence education.

The nineteenth century brought an era of great changes related to educational technology. Apart from printed books and newspapers, which were prior to that time the most commonly used media to transfer information, another technologies begun to gain importance. At the beginning of the century, boxes filled with white sand were used in the U.S. to practice alphabet, as they were the most affordable at the time. These sandboxes were later replaced by individual slates, which even though were a more costly option, allowed students to practice their writing more easily with a chalk, instead of finger [1]. While the slates were used in classrooms since early 1800s, the chalkboards were introduced in 1841 and became a permanent fixture in the classrooms ever since. Along with blackboard gaining popularity during the late 1800s, another important educational tool was a magic lantern. A predecessor of image projectors as we know them now, it was being used for educational purposes until mid-20th century [2].

Soon after the start of the 20th century, new technologies began to emerge again. Among them, radio was the first electronic medium used to teach at a distance. Since as early as the 1920's, various universities and radio networks begun to broadcast their own educational shows. This was of great importance especially to people living in the rural areas, such as farmers and ranchers [3]. Another technology, that followed in the footsteps of the radio broadcast as an emerging long-distance teaching technology was television. Although the main focus of most of the TV channels was rarely education, certain channels built their reputation as an important supplement to traditional education. From simple shows for children that were designed to educate through entertainment, to channels focused solely on documentary movies, nature or history, all of them have been source of knowledge for the last few decades. In contrast to the children's television shows from the 1940s and 1950s, which were focused on pure entertainment rather than smart education, since 1960s television shows help children enhance their vocabulary, teach them morals and increase thinking [4].

Technological advancement is unstoppable, therefore it was just a matter of time before new technologies changed the education again. The emergence of affordable cameras, video recorders, cassettes and compact discs was another milestone in the evolution of the education. They created a new and exciting method of instruction and are still in use even now. From there, it was just a step away from what we now know as on-line education. Following the introduction of everyday-use computers to the market in the 1980s and first mass-market laptops in the same decade, since removing the restrictions on the commercial use of the Internet in 1993 it began to percolate into mainstream society. First conceived as a means of sharing information mostly among scientists and researchers across the world, there were 3.9 billion users reported in 2018 [5]. Similarly, U.S. National Center for Education Statistics states that in 2015, 94 percent of children ages 3 to 18 had a computer at home and 61 percent of children ages 3 to 18 had internet

access at home [6]. Considering the amount of students having access to a computer with the internet connection, it is important to evaluate the role technology plays in education. It can be integral in achieving significant improvements in productivity and can positively impact student engagement, as it ushers fundamental structural changes. Digital learning tools, such as computers and hand held devices, which are growing in popularity since the late 1990s, can be the right tools to bring another revolution in education.

Nowadays, mobile devices are more affordable than ever and thus provide various advantages for both teachers and students. M-learning (mobile learning) and e-learning (electronic learning) are growing in popularity as both allow students to study at their own pace and make the learning process much more enjoyable and compelling experience. It has never been easier to move the class outside traditional classroom environment, or easier for students to study from home.

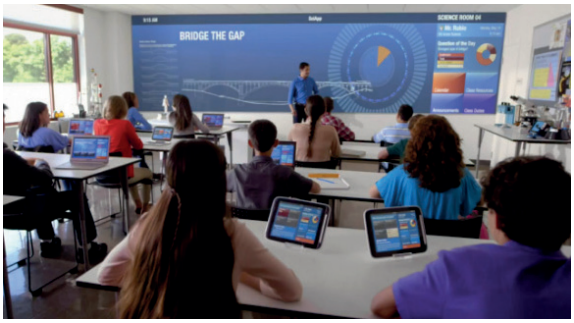

Figure 1. Example of educational technology in class [7]

Young people's love for gaming and technology makes it a great tool for learning. Since the introduction of augmented and virtual reality in education, the classroom learning experience has undergone immense change. Unlike images in textbooks, the opportunity to visualize and interact with the virtual elements provides unique experience and stimulates students' intellectual curiosity. Combined with gamification elements, such as badges or levels, it can greatly encourage learner engagement towards the learning process, provide motivation, experience and positively impact user's cognitive process.

A. *Electronic learning and mobile learning*

Although e-learning and m-learning are often used interchangeably, they can differ in certain aspects. Both falling under on-line education and distance learning (also known as d-learning), certain things need to be considered when trying to differentiate them. E-learning offers distance education using digital device, such as desktop computer, laptop, smart phone or tablet [8]. When looking into the matter, one can found various definitions of m-learning. Some define it as only internet based or wireless. Others argue, that while it must provide the ability to learn anywhere using a mobile device (for instance a smart phone or a tablet), this has to be achieved without the necessity of internet connection [9]. However, it has been acknowledged that m-learning is a subset of e-learning as both rely on teaching using digital communication.

B. *Full-time on-line schools*

These schools are gaining popularity between university students in need of flexible schedule, or high school students that have problems with bullying, commuting to school due to various reasons, or lack of quality schools in their area. Students of on-line schools have also various benefits, such as on-on-one attention from teachers, working with technology and cheaper study materials that are on-line, thus accessible anytime from anywhere.

C. *Supplementary learning*

Usually serves as a supplemental education to regular school. Particularly, this kind of education is usually a one-time course on a certain subject and serves to improve knowledge of aforementioned subject, or a summer school program.

D. *Blended learning*

Also known as hybrid learning, it is a combination of face-to-face learning with on-line education, while trying to implement the best of both. Students can have on-line access to all materials and work outside of classroom if necessary, while still having some time with their peers to help them socialize [10].

II. GAMIFICATION

Although this word is commonly being used, the definitions often wary. Deterding et al.(2011) define gamification as an informal umbrella term for the use of video game elements in non-gaming systems to improve user experience and user engagement [11]. Such video game elements can be, for example, points or awards, which player receives after successfully completing a task or levels with increasing difficulty. The purpose of using these elements is to increase engagement and increase the willingness to return on numerous occasions.

A. *Educational applications*

Nowadays, there's abundance of educational applications that use gamification examples. The ones that regular user can easily encounter are, for example, language learning applications. Whether it comes to the most popular ones, such as Memrise and Duolingo, or less popular ones like ChineseSkill or Drops, all of them use some kind of gamification elements. Skill points received after completing a lesson, daily bonuses, free pro-subscription for a few days after completing a task, they serve only one purpose - to keep the user entertained so he will use the app as long as possible, ideally also buying the paid version. And when it comes to the paid versions, sometimes the offer implementing the gamification elements is even broader. For instance, a Chinese language learning app ChineseSkill can be a good example. Whereas a free version of the app contains only learn section, where user can learn new vocabulary and receive points, the paid version contains also a game section and immersion section. These games challenge users to read the Chinese characters, write them, finish the sentences and various other things and reward them with the in game

currency. To capture the user's attention, these applications often rely on cute visuals with playful colors and user-friendly interface.

III. Augmented Reality

AR is a new technological system that allows inserting virtual elements in the real world in order to run in the same representation and, in real time, enhancing the user's sensory perception of reality. As such, AR can also be defined as a set of tools that augment the visual field of the user providing an interactive experience. This can be experienced either using a hand-held devices, such as tablets or smart phones, or by a head mounted devices, for example smart glasses or headset computers. Some of the popular AR devices that are already available include Oculus Rift and Microsoft HoloLens. On the other hand, some of the most anticipated ones are Magic Leap Lightwear, Google Glass Enterprise Edition and Vuzix Blade AR.

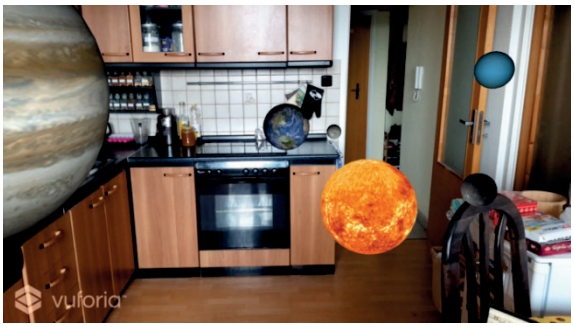

Figure 2. Solar System AR game

A. AR in education

As modern technologies become more and more a part of education, the same is true for AR. From elementary schools to universities, all of them begin to incorporate AR in education due to its many benefits and opportunities it provides.

1) Some advantages of AR:

- Catchy visualization - the use of 3D models instead of 2D imagery can turn even the most boring topic into something interesting and fun. Vivid illustrations, combined with animations and possibilities to interact with them change the way we though about education. AR applications can be accessed by any smart phones or iPhones, therefore students can learn even from outside the classroom.
- Interactive models - whether is it a change in size, scaling, color or orientation, AR can do it all and even more. Being able to look into a car engine, or highlight the nervous system of a frog, these are only some examples of how AR can have a huge impact on manufacturing, medicine and other fields of industry.
- Cheaper study materials - the prices of learning materials can create a lot of difficulties especially for university students. Along with that, study supplies have a tendency to wear over time, so AR can be a permanent solution to this problem.
- Language integration - with reliable online translating software being available even now, new languages can be integrated into any AR application in quick and easy matter.
- Accessible material - compared to digging through a book, searching for a keyword makes information more accessible and digital visualization simplifies the effort needed to understand the materials.
- Creativity boost - new technology can bring a bit of fresh air into classroom and make the learning process more exciting, thus positively impact students' intellectual curiosity, while also possibly reducing the stress for the students [12].

IV. Development of AR Game

To combine the best of AR advantages with gamification principles, we created an AR representation of our Solar System. Apart from running the simulation of the Solar System, the app allows user to interact with every planet and receive basic information, which is later tested in multiple choice quiz. The application was created using Unity game engine along with C# scripts and Vuforia software development kit. It is built for Android 5.1 'Lollipop' an up.

A. Game mechanism

After starting the game, the player is presented with the main menu. First option is an AR model of the Solar System. User can view a simulation of the movements of the planets and upon clicking on each planet, short description is displayed.

Second option is the quiz. When this option is selected, the player is presented with a set of questions about each planet. To win the game, it is necessary to correctly answer 3 questions for every planet, so 24 questions in total. The player starts with three lives, so he can make a three times through a game. To make the game easy to navigate, it is controlled mostly by tapping the on-screen buttons. In the future, virtual buttons may be implemented instead, but as of now, all buttons in the application are controlled by tapping the screen. To test the application, we chose to use Samsung Galaxy S7, as it supports both Vuforia and ARCore. The device operates on Android 7.0 Nougat.

B. Implementation

To be able to navigate the application, we decided to first create the main menu by creating a Menu scene. In Unity, each scene contains various environments, elements and objects. To put it simply, each scene can be treated as a separate level in a game.

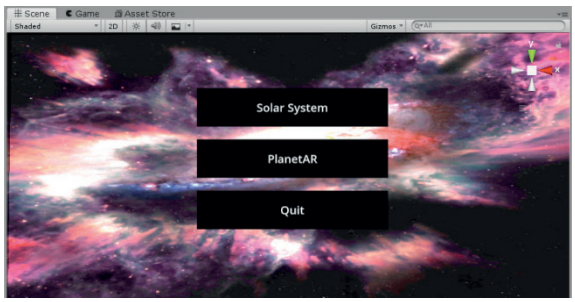

Figure 3. Menu screen of our AR application

V. CONCLUSION

As shown by creating the Solar System application, AR provides endless opportunities to create immersive learning tools. Combining AR with the latest trends in educational technologies can be a beginning of a new era, where education transforms a monotonous lecture into more effective and engaging experience. With the application we programmed, we were able to create a self sufficient educational environment, which can be easily adapted to be used all over the world. It shows only a small glimpse into how modern technologies can be used in education, whether it's on-line, or in class. Furthermore, the constant drop in prices for these technologies and additional hardware makes them accessible as never before, thus creating an ideal environment for what might be a huge change in education as we know it. After testing our application between students it is evident, that more than half of them are eager to use new technologies in class. Considering the functionality of our application, it can be further improved by adding options to slower or speed up the rotation of the planets, creating levels in the quiz game, setting time limit for answering each question, or simply by implementing other language versions. In time, this application may be a first step in bringing the AR into education and thus making it more enjoyable for the students while using the technological advantages of this century.

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