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A.R.E.A. - AUGMENTED REALITY EDUCATIONAL ALBUM FOR EXPERIENTIAL LEARNING

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Abstract: *The current paper proposes a new approach of experiential learning, by bringing together the concept of immersive education and an emergent technology: augmented reality. The immersive education tends to resolve the main drawback of traditional education, which is the limited experimentation, and with the help of the evolving technologies, the students can understand the school subjects in a different manner. At present, the theoretical part plays the major role in education, while the experimentation is often ignored or treated superficially, especially when it comes to progressive domains, such as engineering or informatics. By bringing the immersive education closer to students and teachers, they might be able to experience the most important aspects of this domain, in real-time, without sacrificing the good parts of traditional education. The approach presented in my paper is accomplished through an augmented reality system called AREA, which combines the digital and non-digital worlds, in order to foster an interactive and educative way of discovering the inventions that have revolutionized the modern world, thus making students curious about the evolution of modern technology. Using augmented reality, students have the chance to experiment the connection between learning and practicing and how they co-work in order to achieve great success. The application was tested on a group of high school students and on a group of adults specialized on engineering and marketing domains, the results being very intriguing. Besides presenting my system and the way it can be integrated to overcome the current educational challenges (e.g. lack of practical exercises), we also analyzed the use of other existing augmented reality systems, from various domains, that offer similar experiences to the one accomplished by AREA.*

Keywords*: immersive education, augmented reality, school subjects, mobile application.*

I. INTRODUCTION

In the last decade, technology has gained a considerable place in the daily use of humans, which is absent from almost any activity. Its role is to improve the lives of users and save time whenever needed. In education, the technology provides support to all students but also teachers, through an interactive and user-friendly way, such as demonstration tutorials, interactive presentations, online learning platforms or virtual and augmented reality applications.

Currently, traditional education is in a continuous evolution, by joining certain concepts from modern education, which will allow students to acquire knowledge much easier and much faster. However, traditional education focuses on the assimilation of knowledge, sometimes being too much focused on old knowledge that does not arouse students' curiosity, instead of focusing on modern facts that can shape the future of our students. Also, the materials made available to the students are exceeded by the current requirements of the society, many of the information being outdated or incorrect, the children being forced to search for their courses online or on other sources. In order to give students, the chance to learn in a modern way, it is necessary that these textbooks be updated and eventually allow the use of external sources that can improve the learning experience.

Now, students are extremely familiar with current technologies, thus managing to understand concepts much faster and to obtain information in a simple and interactive way. The ubiquitous presence of technology in classrooms has inspired a shift from traditional classroom lectures to integrated digital learning environments. These interactive learning environments present the opportunity to evolve the teaching process through the incorporation of game elements that have been shown to capture user attention, motivate towards goals, and promote competition, effective teamwork, and communication. Gamification and game-based learning systems aim to bring these benefits into the learning and teaching process [1]. Technologies such as augmented reality can be useful tools to promote sustainable development in higher education in terms of various economic, social and environmental considerations [2].

Education should know it must adapt to the demands of the students and offer them experiences like those they have in their spare time. The focus on interactivity should be the main source of motivation of current education, which will allow the society to add new courses, arouse students' curiosity and offer them new experiences. With the help of a smartphone and augmented reality, the concept of experiential learning gives students the chance to take part in interactive courses, which will be easier for them to understand the context of the course. Next to mobile technology, it is thought that these new generation information systems (IS) will take the biggest place in our lives. AR also will be integrated to these systems to augment the information in real world [3]. With the potential of these measures, the educational process will satisfy the curiosity and imagination of both students and teachers, the implementation of modern technologies saving time and resources, which will be allocated to the addition of new courses and improving the learning experience.

My paper presents an innovative system for experiential learning, which uses the benefits of augmented reality by bringing to the students an interaction surplus for the studied course. The application aims to solve some issues faced by traditional education, by applying augmented reality and gamification principles. In the future, it is expected that gamification will overtake the traditional way of learning resulting in issues such as scalability, upgradation of learning modules [4]. In the following chapters, we will study some of the technologies and applications based on augmented reality used in education, then I will present my solution, the AREA mobile system, including testing and validation, along with future improvements, extensions of the system, and my conclusions.

II. AUGMENTED REALITY TECHNOLOGIES APPLIED IN EDUCATION

During the past few years, augmented reality has grown as part of a large ecosystem meant to deliver great content to their customers. This technology is supported on many existing devices, attracting the attention of many users who have never tried this technology before. Together with virtual reality, these two technologies are becoming the main platforms used for entertainment and social, one major role being played on education. By incorporating this technology on a variety of educational fields, we may focus on the experiential learning and help the current students to understand better each subject. In order to apply this technology in schools, a series of applications have been developed, each of them focusing on the most important aspects of education, through an immersive experience. In the following sections are presented a few relevant applications.

Augment Education. This is an application based on augmented reality and its extremely helpful for presentations, projects modeling and 3D design [5]. By using Augment, the students may create their own 3D models which may help them understand better that specific course, having implementations in anatomy, architecture and arts. Also, the teacher may sustain a presentation with his own 3D models just to offer the students his vision regarding the subject. This application is developed specifically for high school and for academics, due to its technical requirements. Augment is available on Android and iOS freely.

Human Anatomy Atlas. This is an application based on augmented reality and its extremely helpful for teaching students about the human body, including the internal organs, bone structure and muscular density [6]. The application is using 3D models of the human body, with which the students

can interact and can follow all its functions. Also, the application has included a questionnaire focused on relevant information, language settings but also the description of some of the diseases. This application is developed specifically for high school and for academics, due to its technical and medical requirements. Human Anatomy Atlas is available on Android and iOS for a price of 25$.

AR Sandbox. In time, people have always wanted to study the meteorological phenomena and to understand the eradiation processes at the surface level, how the nature can alter its form on a much faster rate. To fully understand all these processes and even more, there was developed a system named Sandbox, capable of simulating the changes of different landscapes, how are the valleys flowed and how the water flux can grow [7]. Mainly, it looks like a regular work station, with a scanner and a projector, which has built-in the projection-based augmented reality and a 3D Kinect scanner, which is used to determine the height and the placement of the sand in the basin, to calculate the best projection and to retransmit the information back to the projector, who projects the lines and the colors on the chosen sand model.

Google Street View. Nowadays, the students can learn about the historical events which represented the base of the modern world and they even can admire ancient artefacts, which they can see only in a museum. With the help of marker-based augmented reality, a new perspective over the world with abstract historical concepts, is opened. Between the most important examples we find the sarcophagus of Tutankhamun, London in the Victorian age and even planes from the World War 2 [8]. By using technology, the students and the teachers may be witness historical moments in the Google Street View app, who managed to immortalize the most important events of the period 1940-1945, its representation being extremely real and detailed.

III. A.R.E.A. SYSTEM FOR EXPERIENTIAL LEARNING

A.R.E.A. is an educational system that is using augmented reality with the purpose of introducing the concept of experiential learning and improving the learning curve by applying gamification principles. The system manages to combine both digital and non-digital components by offering the opportunity to experiment the information as a 3D model, rather than just reading about it, in the form of an album and a companion app. The main target of this system is represented by students of ages between 14 and 22, since this system can deliver content for both high-school and university students.

3.1. Architecture

In the development process of an application, the balance between modelling and programming is the wheel that sets everything in motion. Functions are the ways of the system to show the user that he can do much more than just looking at visuals. Due to the complexity of this system, the architecture is divided in two main components, digital and non-digital. The digital architecture is based on three models, all of them being part of Unity native models: Entity-Component-System, Model-View-Controller and Singleton. The non-digital architecture is structured on a personalized model, specifically created for this component, named Read-View-Try. These two components are using specific elements, and with the integration of algorithms, the entire system manages to move on.

3.2. Technologies

During the development of my system, we have used a series of software, each of them being widely spread in the game industry and augmented reality applications development.

Vuforia Engine is one of the most popular augmented reality frameworks currently in use, since its release in 2017 [9]. Vuforia allows developers to easily add and handle features such as: advanced computer vision, image and object recognition, interact with spaces around the world. The platform has native support for both Android and iOS, but also for Windows (UWP). The applications made with this platform can be used both on portable devices and on HMD devices. This framework is

ideally working as a database with augmented objects, which can be added in its personal portal, namely Vuforia Engine Developer Portal. Inside this portal we may find two main components of this system, License Manager which uses an API key necessary for the connection with the database and Target Manager which holds the augmented objects and allows them to be imported into a game engine and used for 3D modeling.

In order to convert the visuals into augmented objects, we used a 3D modelling software for this job, in my case Blender 3D [10]. Since its launch in 1998, Blender has successfully managed to be remarked with its capabilities, such as modeling, animation, motion detection, but also video editing and game design. The software also brings a coding component, meant to improve the operation and orientation of 3D components, by the native integration of Python programming language.

The third technology is the most important one, which is the Unity Game Engine [11]. It is a user-friendly program, capable and easy to understand for everyone, and it does this great thing. Its editor is compatible with all physical operating systems, namely Windows, Mac and Linux, encompassing a whole host of features that provide an immersive experience as well as extremely powerful tools for developing modern, performance-oriented games. Unity offers support for the development of both 2D and 3D applications and offers support in porting these functionalities for all physical and mobile platforms. On the VR and AR side, Unity is used by large industry studios, such as Ubisoft, Oculus, Google, Samsung, to develop VR / AR applications capable of running on current phones, with Unity proving to be the most viable solution when it is about compatibility, flexibility and functionality for the latest and most innovative immersive technologies.

3.3. Functionalities

The functionalities of this system have been developed in order to respect the requirements of an educational system. By following an on-screen tutorial on the first initialization of the application or by reading the instructions in the album, the user will be capable of using the system without any concerns. They will be able to understand better any school subject that has been represented inside the album. In the following sections, we will describe the various scenes of the system and how both components, digital and non-digital are working together.

Non-digital Component. This part is represented by the album itself, where the user finds all the relevant information regarding the subject, some curiosities and the instructions of the app as well. In the largest part of the page lays the marker, represented by a simple 2D image, with the integrated 3D model, which will be scanned by the companion app.

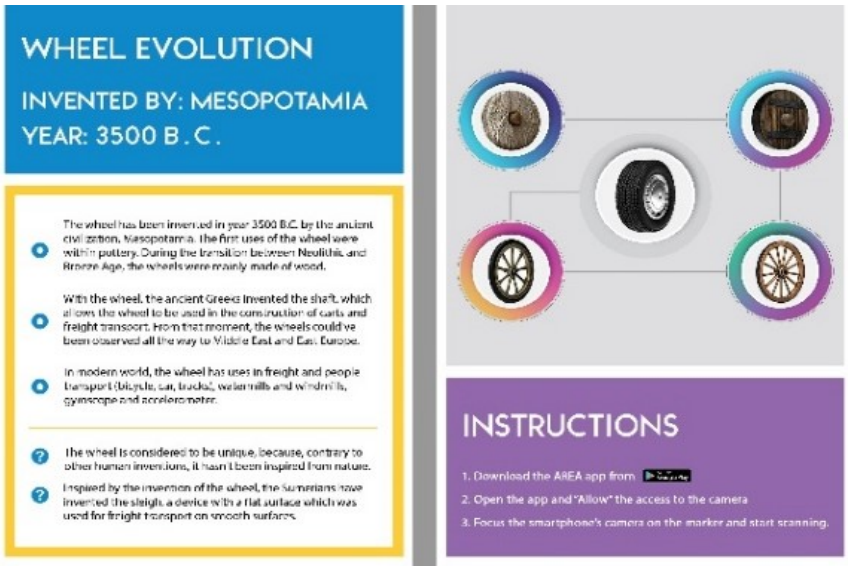

Figure 3 - Non-digital Component (Album page)

Digital Component. This part is represented by the companion app, which the user launches, selects the respective section and starts scanning the marker in order to reveal the 3D model. The

models include animations as well, some of them being extremely accurate so that, the user may have the best experience. Also, the app may also translate the text included inside the album in real-time, this functionality being very useful for foreign students.

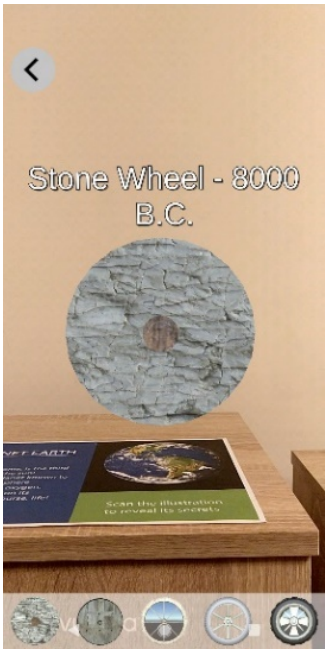

Figure 4 - Digital Component (Companion App)

IV. TESTING AND VALIDATION

The validation has been conducted on approximately 25 people, half of them coming from the educational environment: high school students who were PoliFest participants and students or teachers from the Polytechnic University of Bucharest, the other half coming from a teens programming club. Each of them has been asked the same questions regarding the functionalities and the usability the AREA system could offer. Their answers will be discussed in the following sections of my paper.

4.1. PoliFest event

The project was presented at a local technology conference organized by the Polytechnic University of Bucharest named PoliFest. The presentation helped us start the analysis process in terms of usefulness and public opinion. With the first step of the validation being held at the event itself, the response rate was practically balanced in terms of gender, with men showing interest slightly higher than women. We also noticed that students accounted for most testers with a percentage of 70%, which varied between the first and the third year of study, as age was an important factor, regarding the fact that the target audience of AREA is represented by young people (92% of people were under 25 years old).

During the analysis, the focus was also on AREA user's experience, and if it had a major impact on people or not. They were also asked if they had already had the experience of an augmented reality album, most of their responses being negative (figure 3), fact that proves the need of introducing augmented reality in a greater variety of school subjects. Furthermore, the application was voted as useful (figure 4) because people understand better by practicing then just learning things theoretically.

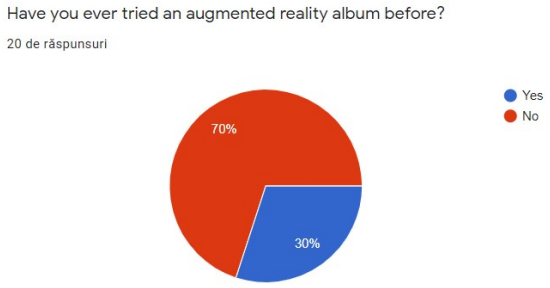

Figure 5 - Users' augmented reality album experience

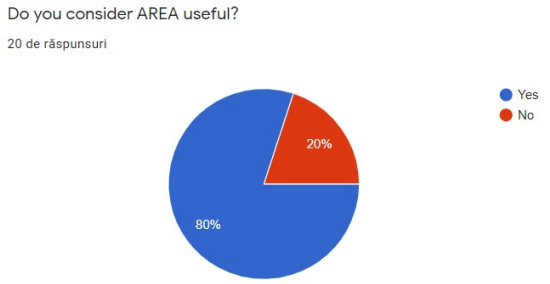

Figure 6 - Users' opinion about AREA's usefulness

4.2. Teens programming club

The project was also tested by young students of ages between 12 and 16. We wanted to know how all concepts that we developed were accepted by the sincerest critics and enthusiastic learners: young people. In order to achieve this, we organized a feedback meeting with a programming club for teens in Bucharest, specialized on the newest educational technologies. We asked the student's opinions after presenting the AREA system. After testing it, all students considered that the application deserves a "good" or "very good" appreciation mark. Furthermore, 90% of them consider that augmented reality can be of great help in the learning process and that it can make some school subjects more interactive and easier to understand.

In conclusion, after the validation process performed in these two steps, the application received almost maximal ratings, the opinion of the testers was considered constructive feedback and the results of this study are a well-established step for future implementations.

V. CONCLUSIONS

In the next period, we will focus on improving the quality of the application, generally focusing on adding new content and implementing useful functionalities. This project will contain a variety of new models, each of them focusing on a specific school subject, including its defining elements. Besides these new models, we will improve the album as well by offering a seamless interaction and extended availability with quicker updates. We will also focus on a different approach which includes the same educational ideas but with the help of a different technology, by developing a new system, capable of using the advantages of mixed reality. We will explore the other face of immersive education and we will try to enhance the vision of traditional and immersive school subjects by implementing augmented elements into the real world. This process will take place on the next couple of years, as it is currently in its incipient phase and hopes to find a better educational solution than the existing ones.

We are hoping that soon more emphasis will be placed on the practical side of education than the theoretical one, and the world will adopt the concept of immersive education to improve the quality of the learning process [12, 13, 14, 15]. Also, by integrating augmented reality into this

process, students will be able to deepen the information more rapidly and devote their time to other recreational activities, hypothesis which is sustained by other researches, too [16].

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