Extended Reality in On-line Education

Ivana Hirjáková [1], Dominik Pružinský [1], Erik Pribula [1], prof. Ing. Gregor Rozinaj, PhD.[1]
[1] 1 Faculty of Electrical Engineering and Information Technology, Slovak University of Technology, Ilkovičova 3, 812 19 Bratislava, Slovakia
xhirjakovai@stuba.sk, xpruzinsky@stuba.sk, xpribula@stuba.sk, gregor.rozinaj@stuba.sk

Abstract - **Modern information and communication technologies influence various aspects of our daily lives. Apart from being used by experts in this certain area, their influence reaches far beyond. While extended reality technology has existed in some forms for over two decades, only recent drop in the costs made it more available. One of the prime examples is recent growth of interest in the use of extended reality in various fields, such as science, education, or military.**

With this growing interest, we can see terms virtual reality and augmented reality being used more and more often in relation to modern education. Key words such as student centric model, gamification, virtual and augmented reality, mulsemedia, remote and virtual labs, measuring the experience of student all play important role in the future of online education on all levels.

I. Education and Gamification

When it comes to education, the main problem nowadays seems to be that students somehow lack the motivation to study. In the United States, almost one third of all public high school students fail to graduate with their class. Some of the reasons why students are dropping out include difficult transition to high school, lack of engagement, no motivation or inspiration to study, and boredom in class [1]. As proposed by Lee and Hammer, one of the possibilities, how to solve the problems around student motivation and engagement may be gamification [2]. The term was first used by Nick Pelling in 2002, but since then has grown within the trends and traditions in games and interaction design.

- Gamification, as defined by Deterding, Dixon, Kaled and Nacke, is the use of game elements in non-game context [3].
- Another definition by Zicherman and Cunningham looks at it as the process of game thinking and game mechanics to engage users and solve problems [4].

What do they have in common is that both underline that gamification is about what makes games interesting and engaging and using that knowledge outside the game industry, not about the games themselves. Furthermore, they focus on using games as a tool to change human behavior and boost productivity, and not focusing solely on the games themselves.

Educational gamification proposes various techniques how to shape learner's behavior. By providing the learner with a game requiring active experimentation and discovery, the game helps to develop their cognitive area. Hand in hand with playing games comes losing, which along with other factors, can invoke a wide range of emotions. By playing games, students may learn to overcome their negative emotional experiences and even transform them into positive ones. Also, by offering the opportunity to try new identities and roles, students gain insight and new vantage points [2]. Taking all this into account, with proper approach gamification can help students engage in the classroom, overcome their problems with studying and health limitations and turn studying into a pleasant experience. On the other hand, it also gives teachers new opportunities how to reward students, guide them and inspire them to learn.

II. Introduction to Extended Reality

This work is a part of the H2020 project NEWTON, which aims to develop, integrate and disseminate innovative technology enhanced learning. With this in mind, our focus was to bring Extended Reality (XR) into modern education. We focused on the main elements of XR, such as Virtual Reality (VR) and Augmented Reality (AR). Our goal was to create AR and VR applications focused on elementary level education, and web application with a database, which can store students' progress. We aimed to connect these three elements and create a self-sufficient platform, which can be used on daily bases. As a common theme of our applications we chose the Solar System, so the language variations of our project can be used all across the world. Both AR and VR applications are interactive games, where student has to utilize the knowledge provided by the study materials available in the web application in order to win the game.

III. The Difference Between AR and VR

To be able to understand the goal of our work, it is necessary to establish the terms we describe in this paper. While trying to explain what virtual reality is, one may stumble upon various definitions. For the sake of this work, we settled on the most used portrayal, thus describing it as a medium, allowing its users to immerse in the artificial, computer-generated simulation and interact with it [5]. On the other hand, augmented reality, as the name suggests, adds (or augments) to the real world computer-generated elements. As Azuma defined it, AR is a variation of VR but in contrast to it, AR allows the user to see the real world, supplementing the reality by superimposing virtual objects into it [6]. Taking this into account, it's easy to distinct these two technologies, when confronted with them. As of now, the best VR experience is provided by a VR headsets, which are getting increasingly popular due to drop in prices, but still may be unaffordable to some. To navigate the VR environment, additional controller (usually hand-held) may be necessary to ensure the best experience. On the other hand, to use an AR application, all one needs is a mobile device, meaning there are far less limitations to AR's usage, thus making it more interesting to the mass market.

Augmented Reality

In recent years, we have seen a huge growth on the market in relation to AR applications. A report by Markets and Markets shows that the market in AR is expected to grow from $2.39 billion (USD) in 2016 to $61.39 billion by 2023 [7].

In addition to utilizing the best of the virtual world, the AR applications combine those assets with the objects in real world, resulting in wonderful experience for user, if programmed well. While using real objects as an image target for our model, we can create interactive models immediately, as never before. With that in mind, the augmented reality app we decided to create works on the same principles. Upon scanning the provided image target a scaled representation of the Solar System can be viewed. Our Solar System consists of basic 3D spheres, which are covered in textures of the planets' surfaces. Each of the planets is interactive and programmed as a virtual object, meaning students can manipulate them solely by hand gestures, as opposed to regular mobile applications, where this feature is handled by clicking the touch screen. Upon interacting with a certain planet a pop-up menu is shown and student can choose from various options. A short description of a planet can be viewed, the same as the materials available in the web application. Knowledge contained in this description will be necessary to complete the questionnaires in the game.

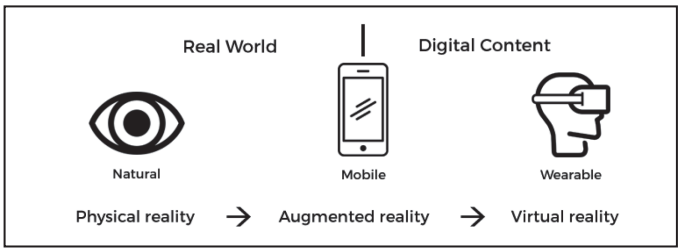

Figure 1. The difference between AR and VR

Virtual Reality

As the AR market is growing, the same goes for the VR market. A report by Statista shows, that by 2021, the combine market size of AR and VR is expected to reach $215 billion [8].

Virtual reality provides technological advances regarding image and degree of immersion that AR cannot offer, which allows us to deal with the restrictions provided by the AR. While being used with proper gear, the opportunities to create virtual environments and engage in them may seem limitless [9].

Following the idea of creating an application similar to the AR game, we created a VR representation of Solar System. Once again, we used 3D spheres covered in textures of the planets' surfaces. However, on the contrary to using real objects and an image target, the VR application offers immersive experience without relation to the real world. By using VR device, student is able to inspect and interact with the planets directly, which both offers him new perspective and also seems far more enjoyable than regular education methods. Instead of using 2D models and visual representations of the planets, students can explore the planets' surfaces and compare their sizes and differences in distance between them.

IV. Development Of AR and VR Games

While focusing on embracing the individual qualities of AR and VR, we created a virtual representation of our Solar System. To make this topic more interesting for young learners, both applications include a game, which allows players to test their knowledge. These applications were created using Unity game engine and C# as the programming language. Both applications are built for Android 4.4 or better. While creating the AR game in Unity, Vuforia SDK was used to ensure the best AR experience. To run properly, the VR application needs peripheral devices, such as PlayStation 4 wireless controller and Google Cardboard with strap.

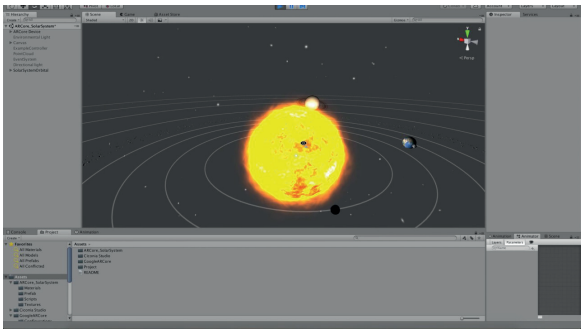

Figure 2. Creating an AR Solar System in Unity

AR Game

Upon starting the game and clicking the planet, student is presented with and AR representation of the player and his enemy, along with a questionnaire. Above the heads of both the player and the enemy are life bars. The questionnaire is made as a virtual button element, meaning player can interact with it solely by hand gestures. This fact helps creating a full AR experience. As the player enters a planet, a set of questions is randomly chosen from the list of questions, based on the study materials presented in the web application. The questions are then displayed to the player and it is up to him to choose the right answer. Each question has only one correct answer and by selecting it, the player deals damage to the enemy. Failing to choose the correct answer or not answering in the set amount of time results in the player receiving a hit. The round ends by answering three questions correctly and thus defeating the enemy and moving to another planet. Before each round starts, player can choose to read a planet's summary, which contains hints to the correct answers.

The main goal of the AR game is to free all the planets of our Solar System from the alien occupation. It is the year 2215 and all the planets are inhabited to some extent, whether being mining colonies, prisons, research stations or military outposts. This situation changes when the Solar System is attacked by a vile alien menace, quickly overpowering powerless human defenders and sending the whole star system into age of despair and darkness. As dire situation as it is, nothing is lost yet, for the humanity still has some hope. This hope comes in the form of our player, the last one to stand against the cruel tyranny. To complete his mission of spreading freedom and democracy

across the system, one has to visit all the planets and answer a set of question about each planet.

VR Game

After putting on the headset and starting the game, student starts in the spaceship somewhere in the Solar System. As a blockade runner, his goal is to visit four locations that are necessary to visit if he wants to win the game. By using the PlayStation controller, it is possible to travel throughout the system and interact with the planets. After flying closely to a planet, the student is presented with a questionnaire which has four options. The questions and answers are based on the study materials, which are provided by the web application. Furthermore, these questions are randomly generated from an XML document, so even though student plays the game more than once, it is unlikely that he will be presented the same questions. Along with that it is also ensured, that the answers will shuffle so the correct answer won't stay at the same place all the time. The aforementioned application is a part of this project and will be available to the student. When correct answer is chosen, next questions is shown until students answers three questions correctly. If incorrect answer is chosen, student get penalization points. While traveling between the planets, navigational arrow can be seen to point student in the right direction.

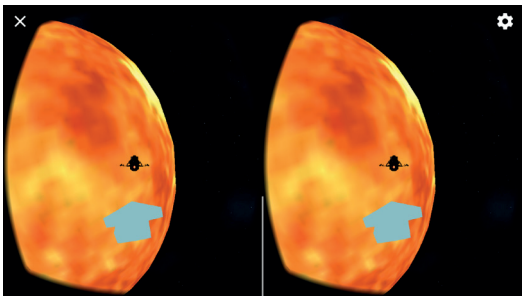

Figure 3. Screenshot from the VR game

The game story is set in distant future, where interplanetary travel is available and affordable. But despite this advancement, the whole Solar System is being torn apart by war. The player starts as a blockade runner between planets in an intergalactic sector-wide cold war. The game starts by giving the player 4 locations of strategic importance, which he all has to visit in order to win the game and save the population located there. On each planet, the player needs to solve a tough quiz, which will test his knowledge and his heart. After passing through the quiz, the player wins over the blockade and delivers the cargo to the planet's population. After visiting every planet, the blockade is over and game ends. The player is subsequently presented with the scoreboard, where he can see his results, along with the penalization and time it took to finish the game. The goal of this game is to provide children with innovative way to test their knowledge along with getting better understanding of the Solar System, and improve their creative thinking and imagination.

V. WEB APPLICATION

The main task of this part of the project was to provide and educational basis for the AR and VR applications. Each student has a unique identification number and upon logging in, his study progress is stored in a database along with the logging information. This feature allows teachers to regularly check students' progress and at the same time students can save their study progress to continue later.

To fulfill our goal and to finish this project, we created a web application allowing us to add, edit and manage online articles, which serve as educational materials for students. These study materials have been thoroughly prepared and the questionnaires in both AR and VR applications are based on these materials. After logging in, the home page presents user with a recommended article, based of whether the student already read it or not. If the student hasn't read any article yet, he is presented with the first one for each subject. Along with the main article, a list of all articles that are currently available is also shown. This list appears on the side and contains links to article. When a certain article is chosen, the user is redirected to it and the application marks the time each user opened and closed an article.

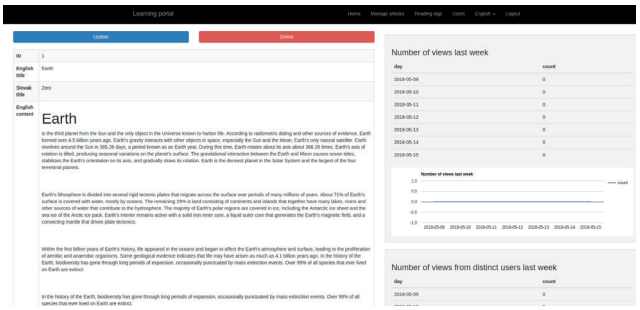

Figure 4. Screenshot from the web application

Taking note of the time of opening and closing an article allows us to keep track of how many articles each user read, as well as the amount of time spent reading them. The information is being stored in tables and graphs and can be viewed by user with special privileges. Apart from this, these privileged users can also edit the articles and manage profiles of users with lower privileges. The editing of articles is available directly through the web application interface, using WYSIWYG editor, making the articles easy to edit and the change will be available immediately. This feature makes this web application more versatile, as new subjects can be added frequently without limiting the accessibility to the application. In addition, each user is available to choose the language of the site and the articles and pages will change accordingly.

The application as a whole is written using PHP language and running the Yii2 framework. To ensure the application will look simple yet professional, CSS front-end framework Bootstrap version 3.3.7. was used. Application is available for free and the registration is possible for everyone with email address.

VI. Conclusion

As we discussed in the beginning, the current state of education is not appropriate for the 21. century. With the applications we programmed, we were able to create a self sufficient educational environment, which can be used all over the world. Along with that, we discovered and studied the various possibilities, offered to us by using augmented and virtual reality, whether in education, or in other fields. In conclusion, these applications may be a first step in bringing the extended reality into education and thus making it more enjoyable for the students while using the technological advantages of this century.

The applications created while working on this project show only a small glimpse into how modern technologies can be used in education, whether is it 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.

Acknowledgment

This research was done with support of projects VEGA 1/0800/16 INOMET and H2020 NEWTON Ref. No.: 688503.

References

[1] J.M. Bridgeland, J.J. DiIulio Jr, K.B. Morison, “The Silent Epidemic: Perspectives of High School Dropouts”, Civic Enterprises, 2006.

[2] J. J. Lee and J. Hammer, “Gamification in education: what, how, why bother?”, Academic Exchange Quarterly, 2011, pp.1-5.

[3] S. Deterding, D. Dixon, R. Khaled and L. Nacke, “From game design elements to gamefulness: defining “gamification””, in MindTrek ’11, 2011, pp.9-15.

[4] G. Zichermann, Ch. Cunningham, “Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps”, O'Reilly Media, 2011.

[5] T. S. Mujber, T. Szecsi, M. S. J. Hashmi, “Virtual reality applications in manufacturing process simulation”, Journal of Materials Processing Technology, 2004, pp.1834-1838.

[6] R.T. Azuma, "A survey of augmented reality," in Presence-Teleoperators and Virtual Enviroments 6, 1997, pp.355-385.

[7] “Augmented Reality and Virtual Reality Market by Offering (Hardware & Software), Device Type (HMD, HUD, Handheld Device, Gesture Tracking), Application (Enterprise, Consumer, Commercial, Healthcare, Automotive), and Geography - Global Forecast to 2023”, MarketsandMarkets, 2018.

[8] Statista, “Forecast augmented (AR) and virtual reality (VR) market size worldwide from 2016 to 2021 (in billion U.S. dollars)”, Survey, 2017.

[9] M. Fairén, M. Farrés, J. Moyés and E. Insa, “Virtual Reality to teach anatomy”, Eurographics, 2017