AUGMENTED REALITY IN PRIMARY SCHOOL GEOGRAPHY: COGNITIVE GOALS AND USABILITY

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ABSTRACT

The purpose of this study was to examine the application of Augmented Reality (AR) Application in the Geography lesson of Primary School. The application covered the Earth's atmosphere and was evaluated by 71 students in the sixth grade of primary school who completed questionnaires before and after the educational intervention. The results were positive, since most cognitive goals were achieved, and application proved to be interesting and easy to use for students. The significance of this study is twofold. A new ready-to-use digital educational tool was created, while at the same time it is one of the few studies that have investigated the efficiency of AR in terms of cognitive and usability goals with a large sample of students.

KEYWORDS

Augmented Reality (AR), Mobile Learning, Geography Lesson, Primary School, Teacher Support Tools

1. INTRODUCTION

In recent years, augmented reality technology has been used in a variety of sectors. Education, particularly play and learning, is one of them, both in new subjects like computer science and in pre-existing ones like geography lessons (Yavuz et al 2021; Hincapie et al 2021; Schnürer et al 2020). Applications are a powerful tool that can be used to complement and support teaching while enriching learning in the learning process (Ramnarain-Seetohul, Nishesh, & Siddish, 2019). Students more easily understand the concepts that are being taught to them, while at the same time, the usual learning process turns into an exciting experience (Roopa, Prabha, & Senthil, 2021).

According to the New Greek Curriculum, the teaching of Geography lesson in modern primary school's concerns both natural and human geography. Its aims are to raise awareness and cultivate students' curiosity about the world (Fokides 2019; Klonari & Koutaleli, 2017; Labrinos & Bibou, 2006). Based on these innovations that the New Curriculum wants to introduce, a new digital educational material was designed based on Augmented Reality technology for the teaching of the unit entitled "Atmosphere" in the geography course in the 6th grade.

This study investigated the role of augmented reality (AR) in the teaching of geography lesson. Its purpose is to design and study an educational scenario using an AR application (App) combined with the printed material of the school textbook in the lesson of Geography in the 6th grade of primary school. Its aim is also to study the effects of AR on the real dimensions of teaching. The research questions that have arisen from the research in the international literature (Table 1) are the following:

- Can AR be used in the teaching of geography lesson, according to the existing Greek educational conditions?
- Are the cognitive goals of the course achieved with the contribution of AR?
- What is the attitude of students towards the use of the AR application?

The contribution of this study is multiple. First, a new ready-to-use digital educational material based on AR technology was created. The theme "Atmosphere" in the geography lesson has not been researched before. In the last five years, only nine studies have been conducted to exploit AR in geography lesson within the primary school classroom, focusing unilaterally on either the achievement of the cognitive objectives or the evaluation of the usability of the application (App), and only one of them evaluated both factors. This

intervention aims to evaluate both parameters and to enrich the existing literature. Finally, it is the second study international with the most significant research sample. All the above reveal the importance of the present work in relation to the previous studies.

Table 1. Studies

Publications	Sample & Age of users	Goals to achieve
Fokidis & Foniadaki (2017)	60 students aged 11 to 12	Cognitive goals
Palaigeorgiou, Karakostas, & Skenteridou (2018)	58 students aged 9 to 10	App evaluation
Herpich, Nunes, De Lima, & Tarouco (2018)	**75** students aged 11 to 12	Cognitive goals
Fokides (2019)	66 students aged 11 to 12	App evaluation
Salazar, Pacheco-Quispe, Cabeza, Salazar, & Cruzado (2020)	54 students aged 10 to 11	App evaluation
Ng, Lee, Cheng, & Ngan (2020)	11 students aged 6 to 12	Cognitive goals & attitude change
Kumpulainen, Byman, Renlund, & Wong (2020)	62 students aged 7 to 9	App evaluation
Ntrenogianni & Zerva (2021)	15 students aged 11 to 12	Cognitive goals & App evaluation

2. METHOD

The purpose of this paper is to investigate the cognitive achievements and the evaluation of the new digital educational material, created for the course of geography, based on AR technology. The content of the educational software of the Augmented Reality Application (AR App) was based entirely on the schoolbook of the 6th grade geography lesson in primary school. Since students would have only one teaching hour (45') to deal with the software and complete the pre-test and post-test, it was chosen to augment the three images in Chapter 9 entitled "The Atmosphere" in the student's book. This unit has not been taught again in previous classes.

The design of the AR App follows the usability principles of Nielsen (1995). The multimedia elements were gathered from existing media libraries freely available on the internet. The ZapWorks Studio platform was used to create a 3D virtual Earth enclosed by the mantle of the atmosphere (Figure 1), taking its elements from the website "*CGTrader - 3D Models / 3D Designers"* (https://www.cgtrader.com/free-3d-models?keywords=earth). ZapWorks Designer was used to create 2D digital objects, electronic resources, and videos. First, the book images were uploaded to the ZapWorks Designer website and their ZapCodes were generated for "scanning". The size of each graphic object, its position, the time it will appear and disappear, the graphics' movements, and the type required for the display of augmented content were then defined. In addition, to define the movements of the objects and activate the virtual buttons of the application, it was necessary to create short commands. The mobile App, named Zappar, was used to display the augmented digital objects. The App's size is quite small to install (5.7Mb), while the minimum Android software requirements are version 2.3, with a release year of 2019.

The research lasted three weeks and each class needed one teaching hour. 71 students (39 girls and 32 boys) aged 11 to 12 years old interacted with the AR App in May 2020. The didactic intervention was implemented by four teachers from three Greek primary schools. The participants answered questionnaires before and after the invention. The data from the questionnaires, completed by the students, were analyzed.

Participants played with the enhanced digital environment of the Zappar App in groups of three or four to present new knowledge collaboratively, in a 45-minute session, as part of a daily teaching day and hour at the elementary school where the students were attending. The aim was to introduce AR to current educational conditions. Before and after the implementation, students asked to answer a questionnaire (pre-test & post-test). During the intervention, students scanned the images and interact with the content displayed to them.

Firstly, each student completed the pre-test independently, as one of the research tools for collecting research data. It included five closed-ended assessment questions for the student's existing knowledge on the topic which would been discussed. One of them was about their sex. At this point, it should be mentioned that help was given to the students whenever they asked for it.

Then, students were asked to "scan" the ZapCode of the first image in the textbook and then the image itself. After the scan, the Earth appeared in the image of the book and on the screen of the tablet with its

atmosphere in 3D form (Figure 1). In this way, not only were students given the opportunity for a real interaction with her but at the same time, they were transformed into an experience (experiential learning) Kesim, & Ozarslan, 2012). While the students were working on the 3D object, the teacher leads the discussion and informs them that the topic for discussion is the Earth's Atmosphere.

Figure 1. Augmented 3D digital Earth with Zapcode Scan

Figure 2. Augmented 2D object with Zapcode scan

After that, students scanned the second picture of their textbooks. The teacher indicates the students which digital button they must bush to see the video of each layer of atmosphere. Before watching the videos, they had the opportunity to read an article, through the application. When scanning this image, two-dimensional objects appear to pass in front of the application screen. Each object has its position and use. 2D clouds are moving within the boundary of the Troposphere, a plane in the Stratosphere and a rocket pierce the layer of the Exosphere. Thus, students could see tangibly and realistically exactly what is happening in the layers of the Atmosphere. Pressing each button that says the name of each layer opens a new window for students and a video about the layer corresponding to each button was displayed. By scanning the last image in the textbook, students were asked to press the center button on the 2D Earth and watch the video on the importance of the Atmosphere's contribution to sustaining life on planet Earth (Figure 2).

At the end of the intervention, students had five minutes to answer the post-test. It consists of two parts. The first part has the same questions as the pre-test. The other part consists of closed-ended questions and in particular multiple choice to evaluate students the AR App.

In this research, we adopted quantitative methods to compare students' prior knowledge with new ones, their emotions, and experiences at the end of using the AR application. The data collection tools used are:

- Pre-test scores will represent students' prior knowledge about the subject
- Post-test scores will represent students' learning outcomes after the intervention and their attitudes regarding the use of AR application, at the end of the intervention

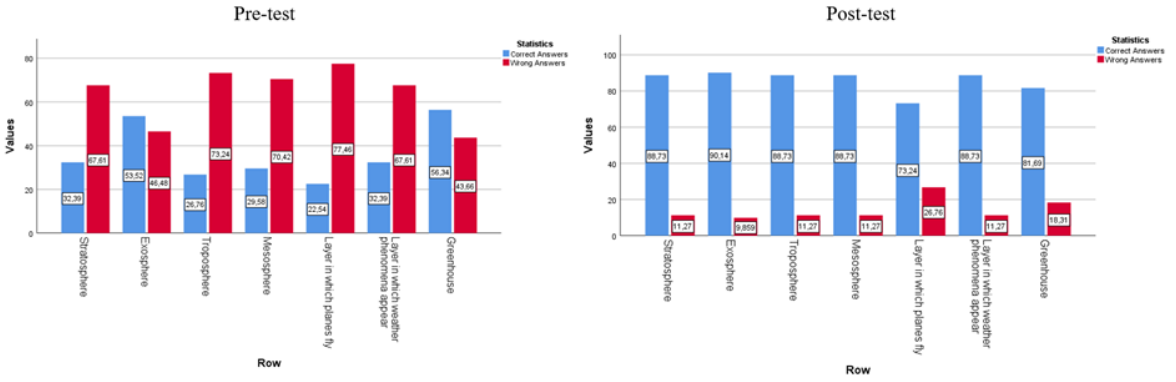
For the collection of research data, children were asked to answer questionnaires before and after the intervention. The questionnaires questions were closed-ended, in the form of single and multiple choice, as well as questions with answers on a 4-point Likert Scale, based on the SUS (System Usability Scale) usability questionnaires, rendered in Greek (Katsanos, Tselios, & Xenos, 2012). In this way, we wanted to evaluate the students' prior knowledge (pre-test) and compare it with the new (post-test). Also, with the questions of the second part of the post-test, our purpose was the evaluation the application and AR in general by the students.

3. RESULTS

The results of the present research prove that the utilization and use of Augmented Reality are suitable for the design of teaching scenarios during Geography because they bring lot of multiple benefits.

To evaluate the achievement of the cognitive goals, a comparison was made between the questionnaires, which were completed by the students before and after the intervention. As we can see in Table 2, in pre-test wrong answers outweigh the right ones, when it comes to knowledge questions. But at post-test, the right answers outweigh the other ones. The software contributed as an aid to the achievement of the cognitive goals that had been set from the beginning, a fact that also confirms the investigations of Fokidis (2019), Palaigeorgiou, Karakostas & Skenteridou (2018), Salazar et al (2020) and Ntrenogianni & Zerva (2021).

Table 2. Questionnaire answers for cognitive goals



According to the last bibliography, AR Apps enhance motivation for learning (Ng et al 2020) and turn teaching into a game (Salazar et al , 2020). The statistics results of the post-test showed that the vast majority stated that class was particularly fun with the help of this AR App (90%), while the 70% of students would enjoy using it frequently outside of class.

Children were thrilled with the use of this AR application, and we noticed that users positively received the app since they stated that they did not have much difficulty while using it. 73.24% of children disagreed with the statement that the application was difficult to use, and correspondingly about 77% stated that it was easy to use. In addition, approximately 74% of students believe that everyone can use it. Also, the students who felt that there is no need to know a lot of new information to use the application range in the percentage of 39.44%, while a percentage of the order of 33.80% declares that they are unsure about this position. At the same time, around 54% of children felt quite confident while using the application.

Therefore, during the evaluation of the application by the students, it was observed that the latter very easily and quickly became familiar with the AR application and how it works. 51% of participants stated that they did not need help while interacting with the application, while 56% of respondents with the rate of complexity, which supports the previous results.

In conclusion, the use of Augmented Reality application, according to the current educational data and needs, proved to be particularly helpful for the learning process. All data are positive for the effectiveness and ease of use of the application by students.

4. CONCLUSION

The results of the present study show that the utilization and use of Augmented Reality is suitable for the design of teaching scenarios in Geography because they bring a lot of learning benefits, enhance motivation for learning and turn teaching into a game. We observed that most of the cognitive goals were successfully achieved. Students understood the function of the atmosphere in terms of its composition, structure, and its role in sustaining life on planet Earth. They were also enthusiastic about the AR App. Overall, the use of Augmented Reality, according to current educational data and needs, proved to be particularly helpful for the learning process.

However, some elements have fostered reflection. The most important of these is the relatively large amount of time spent building applications due to a lack of experience in designing such interactive environments. Despite the difficulties that the use and construction of these applications may have, the necessity of adopting such educationally correct applications during teaching becomes apparent. The sample, although sufficient for statistical analysis and from the largest samples so far, is considered relatively small and unrepresentative, while the possibility of generalizing the results is limited. Therefore, it is necessary to conduct further studies with a larger number of participants to generalize the results.

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