Impact of the Implementation of Resources with Augmented Reality in Education

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Abstract. Augmented reality (AR) has shown positive effects in education. In the present investigation, the results of an educational intervention, which consisted in the implementation of AR resources in the teaching process, are presented. The research had as objectives A) to analyze students' perspectives on the implementation of AR in the educational field; B) to design resources with AR with the participants, as products of their projects; and C) to compare the performance of students doing projects with AR with their performance in a project done previously. The study was carried out with a population of 39 students between 12 and 16 years old who developed research projects on various topics in which they had to develop a product as the result of their research. The duration of the project was 6 weeks, for which the students worked in groups with the PBL methodology. To collect information about the learning experience, a survey was applied to the participants at the end of the intervention. Products, because of the project, were developed and presented by the students, and the grades obtained in the development of the project and qualifications obtained in previous projects were compared. Once the results were analyzed, it was evident that A) the vast majority of students surveyed gave answers in favor of the use of the technology to improve their motivation to learn, which significantly improved their willingness to carry out learning activities; B) the products developed were brochures and posters assembled with AR resources; and C) an increase of 2.24 points in the course average occurred in relation to the previous project.

Keywords: Augmented reality · Education · Innovation

1 Introduction

The educational context is currently going through a restructuring of its paradigms. It has gradually incorporated into its process different resources, methodologies, and tools linked largely to educational technology, which, during the COVID-19 pandemic, was

accelerated because of educational activities in isolation migrating to virtual settings [1]. Various studies have suggested that the use of different technological tools improves the learning experience of students as well as their motivation and predisposition to learning [2, 3].

In the range of resources and platforms offered by technology, augmented reality (AR) is found. It has been implemented with positive results in various areas of education, such as anatomy teaching [4], literature, reading comprehension, immersive learning [5], preschool education, the creation of educational video games [6], and emotional intelligence [7] to cite some examples. Consequently, it can be mentioned that the use of this technology could facilitate the understanding of scientific concepts, since it complements the student's sensory perception of reality by incorporating computer-generated content into the environment. This offers a new form of interactivity between real and virtual worlds [8, 9], which, for the educational field, represents an innovative way for the teacher to present to students the contents to study [10] by combining them with methodologies such as gamification [11], PBL, or educational approaches such as STEAM education. At present, in the rise of digital technologies, technological tools can be considered powerful instruments at the service of education due to the ease and speed they offer to access information in different formats, as well as the various possibilities of immediate communication that they allow, the sharing of information online, etc., thus contributing to optimization of the teaching and learning process [12].

Next, the characteristics of AR platforms and applications to create resources are presented, as well as the benefits of the application of AR in learning. Later, the results found in the investigation are detailed.

1.1 Augmented Reality

AR can be defined as a technology that enables the combination of virtual objects and real objects in real time through technological devices [13]. AR all ows reality to be completed without replacing it, unlike virtual reality (VR), which immerses the individual in a non-real world in which one cannot see the world around [14]. Other authors define AR as the interaction of audio, graphics, text, and other virtual elements superimposed on reality, where objects can be displayed in real time. In reality, some AR applications use mobile devices such as smartphones and tablets to allow the user to interact with digital information integrated into physical space [15].

It is necessary to differentiate VR from AR, since the latter combines digital information with the real environment [16], unlike VR where the individual accesses information through an immersive, simulated environment.

1.2 AR Platforms and Applications

There are various platforms and applications that allow the development of resources with AR, among which we can mention mywebar.com as well as unitear.com [17], which are platforms that allow users to create resources with AR on triggers or activators created with QR codes, on images, on curved surfaces, or superimposed on real-life objects. The platform mywebar.com allows one to place images, text, audio, video, 3D models, and 360º images on the triggers or to create complete AR scenes, as shown in Fig. 1 [18].
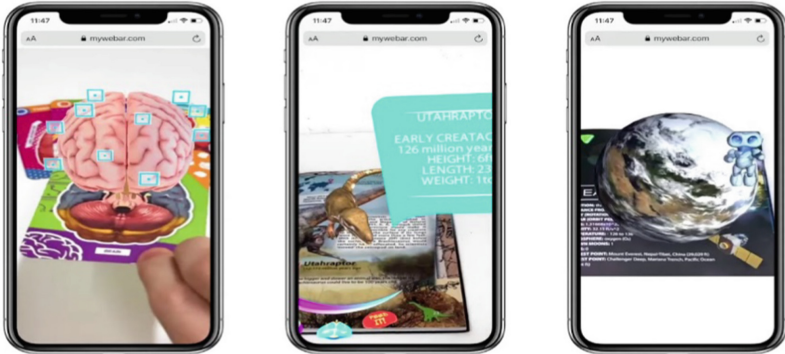
Fig. 1. AR resource platform mywebar.com

Mobile applications such as Quiver Vision [19] already present AR animations that can be used by the user. In the case of this application, the triggers are images of various themes such as cells, coloring drawings, and volcanoes, among others, as shown in Fig. 2. These AR animations can be used by students in the educational field.
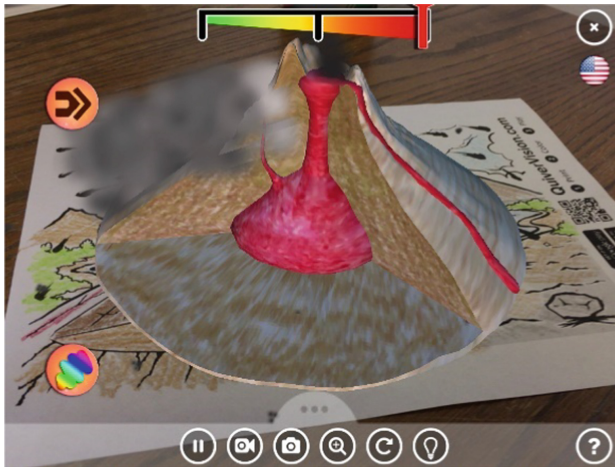

Fig. 2. Image with AR application Quiver Vision

Like this application, one can find many more that can be implemented without difficulty in different educational areas, depending on the content of the application. For example, the Animal 4D + application shows cards with AR animation of animals, and the AR application Cam 4D + is an AR camera application that allows one to create an AR environment anywhere and anytime. We also have the Humanoid 4D + application, which has AR resources on the human body (see Fig. 3). All these applications are from Octogon Studio [20]. In the case of Raap Chemistry, the application allows visualizing the anatomical structure of all the elements of the periodic table.

Fig. 3. Humanoid 4D +

1.3 Application of Augmented Reality in Education

In the table 1 the reader will find in detail the main findings in recent studies on the application of AR in education.

Table 1. Studies on the application of AR

Research title	authors	research	findings
Educational video games for girls and boys in preschool education using robotics and augmented reality	Méndez-Porras, Alfaro-Velasco, & Rojas-Guzmán, 2021 [6]	The objective of this work is to help preschool teachers strengthen STEM education in girls and boys through the use of a video game on topics from the didactic guide of public education	The first results show that functional video games can be developed using these technologies and following the didactic guide for preschool education
Augmented reality as a resource for training in higher education	Martínez Pérez, Fernández Bárbara, & Borroso, 2021 [13]	Measure knowledge students have about emerging technologies, specifically AR design; produce and apply digital objects in AR; assess the usefulness, potentialities, and limitations offered by the application of AR in higher education	AR can enhance collaborative group work creating inclusive scenarios and contexts

(continued)

Table 1. (*continued*)

Research title	authors	research	findings
Augmented reality system for teaching mathematics during COVID-19's times	Naranjo, Robalino-López, Alarcon-Ortiz, Peralvo, & Garcia, 2021 [21]	This article develops an AR system based on the Singapore method for teaching exact sciences	The students improved their academic average when using this type of tool
Comparing reading comprehension between children reading augmented reality and print storybooks	Delneshin, Hamid, Yazdan, & Hassan, 2020 [3]	Measures the reading comprehension of children reading an AR storybook and compares it to their counterparts reading the traditional print version of the same book	Children who experienced an augmented storybook were better at retelling and answering comprehension questions
Augmented reality as a support resource in the teaching-learning process	Hidalgo-Cajo, B., Hidalgo-Cajo, D., Montenegro-Chanalata, & Hidalgo-Cajo, I., 2021 [4]	The main objective of the research is to design, implement, and evaluate a didactic proposal based on AR; we worked with an intervention group and a control group	The control group obtained an average of 2.77 out of 10, while the experimental group obtained an average of 7.97 out of 10; The students considered that the AR resources aroused motivation in them
Literary education and reading promotion supported in immersive literary environments with augmented reality	del Rosario- Neira & del- Moral, 2021 [5]	To analyze 25 ILE created by future teachers aimed at promoting literary education and reading in preschool education; determine the level of satisfaction of future teachers at the end of the experience, through a survey	The innovative experience was very successful for pre-service teachers, who took advantage of AR opportunities to design activities for literary education and promote playful and multisensory learning
Innovation in the university classroom through augmented reality: Analysis from the perspective of Spanish and Latin American students	Cabero-Almenara et al., 2021 [22]	To analyze the experiences of university innovation with immersive technologies (AR) of various careers of the Pablo de Olavide University (Spain) and the Catholic University of Santiago de Guayaquil (Ecuador)	The advantages of AR perceived by students were the development of cognitive and digital skills

Table 1. (*continued*)

Research title	authors	research	findings
Impact of augmented reality technology on academic achievement and motivation of students from public and private Mexican schools: A case study in a middle-school geometry course	Ibañez, Portillo, Cabada, & Barrón, 2020 [9]	Design of an AR application for students to practice the basic principles of geometry, and contrast it with an application implemented in a web-based learning environment	Students using the AR-based learning environments scored higher on the post-test than those using the web-based application
MantarayAR: Leveraging augmented reality to teach probability and sampling	Conley, Atkinson, Nguyen, & Nelson, 2020 [23]	The purpose of this study was to explore whether AR learning experiences can support learning for college-level students	Participants assigned to an AR experience condition reported a statistically significantly higher perception of engagement
EmoFindAR: Evaluation of a mobile multiplayer augmented reality game for primary school children	López & Jaen, 2020 [7]	The use of markerless mobile AR to improve the socialization, communication skills, and emotional intelligence of primary school children	The collaborative game version had a greater impact on the emotional affection, social interaction, and interest of the participants
Augmented songbook: an augmented reality educational application for raising music awareness	Rusiñol, Chazalon, & Diaz, 2017 [24]	Development of an AR mobile application that aims to sensitize young children to the abstract concepts of music	The application allowed the superimposition of increased content on pages of a songbook, which allowed obtaining positive results in the participants

1.4 Benefits

The field of AR has gained great relevance in recent years. Various investigations have found significant benefits with the application of AR in education, such as the study carried out at the Pablo de Olavide University of Seville (Spain) and the Catholic University of Santiago de Guayaquil (Ecuador) in which different AR applications were evaluated. The students indicated that they perceived the development of cognitive and digital skills as benefits of the application of AR in education [22]. Other studies have indicated that students considered that AR resources arouse in them the motivation to use them due to their ease of use and the interaction they experience between content and virtual objects, generating knowledge with entertainment [4].

1.5 Limitations for the Implementation of Augmented Reality

Among the limitations to successfully incorporating different AR resources in education are the digital skills of teachers in the use of technological tools. Thus, continuous training of teachers is inherently necessary because when they understand the application of technological resources as well as the management of teaching methodologies linked to a technology, better learning results can be expected when these resources are used [4, 6].

2 Investigation of Hypotheses

Base on the intervention carried out, it was projected that the students would benefit by the technological educational process, which would improve their average performance when comparing their measurements in the development of two projects, one with the incorporation of AR and the other worked in a traditional way. In the same way, it was expected that students would positively perceive the incorporation of AR resources in their learning process.

3 Methodology

Quantitative research was carried out in which a questionnaire was applied to identify aspects such as the educational benefit, motivation, and taste of students regarding the use of AR in their learning. The averages obtained by the students in the development of two projects, one without intervention with AR and one developed with an AR intervention, were compared.

There was a population of 39 students who consented to their voluntary participation in the intervention. The students were in a range between 12 and 16 years of age. All participants belonged to the E.U. Reply May 24 to the fiscal educational system of the city of Quito, Ecuador.

4 Results

Table 2 shows the response frequencies in the survey applied to the participants.

Figure 4 shows the percentages corresponding to the responses obtained in the survey.

Table 2. Results found in the applied questionnaire

Item	Answer frequency				
	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
Q1. Have you had any previous experience using augmented reality activities in the classroom?	25	12	2	0	0
Q2. Do you think that the use of augmented reality resources encouraged your participation in the learning process?	25	12	2	0	0
Q3. Did you feel motivated working with the augmented reality resources?	21	13	5	0	0
Q4. Did you like the activities that could be carried out with the augmented reality resources?	25	8	6	0	0
Q5. Would you like to work on other projects with these resources?	21	12	3	1	2
Q6. Do you consider that you were able to learn the topics studied, with this way of working?	24	14	1	0	0

(*continued*)

Table 2. (*continued*)

Item	Answer frequency				
	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
Q7. How would you rate this learning experience with augmented reality resources?	23	12	4	0	0
Q8. Did this learning methodology generate frustration?	0	0	4	12	23
Q9. Did this learning methodology generate motivation?	21	11	7	0	0
Q10. Does the application of these resources in education seem innovative to you?	27	9	3	0	0
Q11. Are you interested in learning how you could use this type of technology in other areas of study?	29	10	0	0	0

The vast majority of the students surveyed gave answers in favor of the use of the technology to improve their motivation to learn, which significantly improved their willingness to carry out learning activities.
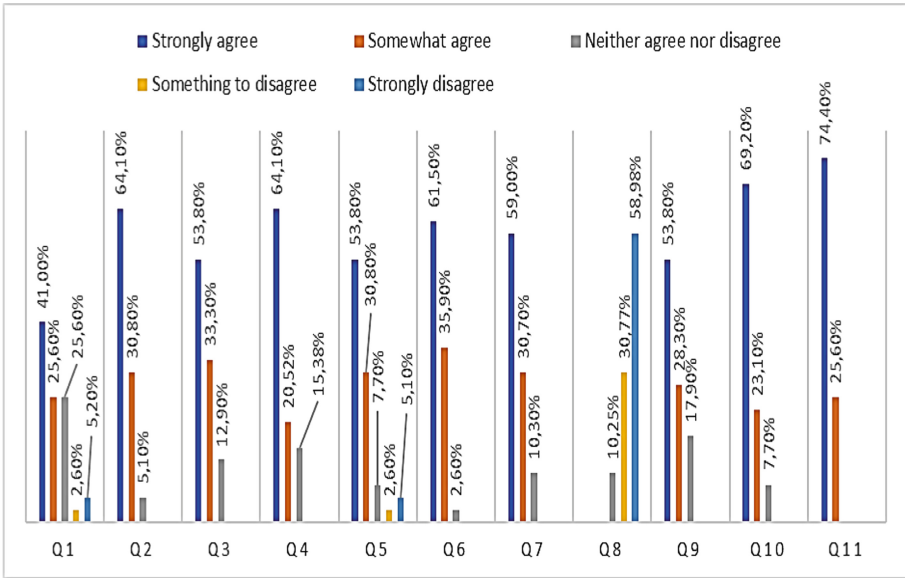
Fig. 4. Results found in the applied questionnaire

On the other hand, as products developed by the students, we find brochures, posters, buildables that incorporate ima ges, audio, text, video, and 360° images in triggers or activators in QR made with applications such as me-qr.com and mywebar.com. Figure 5 shows images of the work carried out.

Finally, we compared the averages obtained by the students in the development of the two projects: a project carried out before the intervention, which was worked in a normal way, and a second project developed incorporating AR resources.

In the development of the first project, the group obtained an average of 7.23 out of 10; in the second project, the group obtained an average of 9.47, increasing its performance by 2.24 points, which can be seen in Fig. 6.
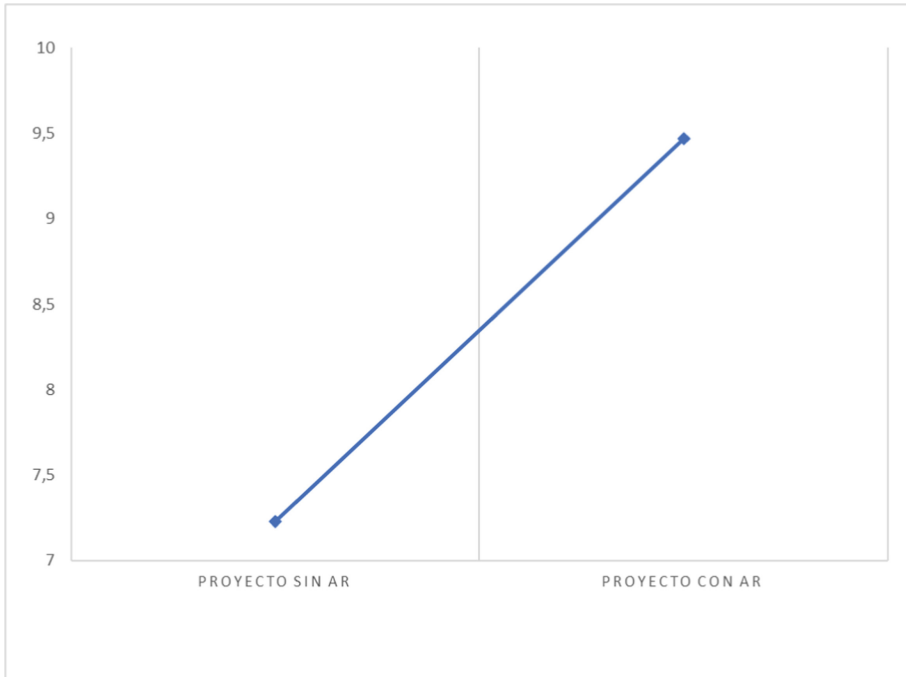
Fig. 5. Works developed by the students

Fig. 6. Average obtained in project without AR intervention and average with AR intervention

5   Conclusions

In this article, we have reported the results of a research study that analyzed student perceptions of the use of AR resources in their learning process. The students were able to successfully develop resources with novel and useful AR elements for their training.

A high percentage of students expressed favorable responses regarding the use of AR in the teaching-learning process. The vast majority agreed that the use of AR improved their motivation to learn and increased their willingness to carry out learning activities. In general, they indicated that working with AR was a positive experience and that they would like to apply these resources in other areas of study.

The comparison between averages suggested the benefit of using these types of technological strategies in the teaching and learning process. These innovative practices generate a real challenge in the educational process since it is necessary, in the local context, for the migration of many traditional processes toward technological resources.

As future research, it is proposed to extend this type of intervention to other areas of knowledge and to a larger population; similarly, it is proposed to evaluate the usefulness of AR mobile applications for students.

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