

Application of Augmented Reality in Teaching and Learning in Engineering Programs

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Abstract—Augmented reality is one of the new emerging technologies in the world, since its appearance was considered for many years its application in education as a tool in the student's learning process. Taking these aspects into account, the present research article was developed, which is based on the design proposal using augmented reality in the learning process at a university in northern Lima. In which the analysis, architecture and development of a prototype was showed in detail. The study of the research focuses on covering the gap that is the lack of promoting augmented reality courses to replace the traditional one. This main finding is important for decision-making by university authorities in the use of augmented reality. The result of the article was obtained by means of surveys, in the first survey it was demonstrated that the augmented reality is an unknown technology for several of the students and the feasible use in the distance education as a support in the classes, in the same way the second survey demonstrated a high interest on the part of the students at the moment of using this technology in its learning of university formation. The contribution of the research is the realization of augmented reality through a pilot with some courses, and then it can be radiated to the other faculties of the university under study. In this way, the University, teachers and students benefit.

Keywords—augmented reality, distance education, learning, teaching, university formation

1 Introduction

It might seem that augmented reality (AR) is a new technology that has appeared in recent years, but it is not. The first research work that implemented augmented reality, technology was in the 1960 by Ivan Sutherland at the Massachusetts Institute of Technology and Harvard University. To summarize, it is a debatable topic among researchers, science professionals and society, since its appearance attracted attention, but it was not until 1992 when the term AR first appeared to define a technology that allows increased user field of vision in real time [1]. The first research work on augmented reality was done at Columbia University, so it can also be considered one of the first examples of augmented reality in education.

This technology is planned to be implemented in the educational system, since it promotes support to improve teaching and learning, in order to easily understand theoretical concepts and mainly to show students professional careers where they can have simulated learning experiences [2]. In higher education, augmented reality is a promising tool that seeks to complement learning and teaching in engineering programs. It also helps students to enjoy their real environment [3], [4]. Its use opens a lot of possibilities in several fields, such as medicine, engineering and architecture, among others, [4] which has led to change the curricula in universities and institutions to make them more attractive, and adapt them to the needs of students for their professional training.

At a global level, due to the new coronavirus COVID-19, several economic and social activities have been paralyzed [5], within which classroom education has been one of the most affected in the world [6].

In this way, students can learn and develop computational thinking skills, as it will help to solve problems optimally through technological processes so that the applications will have a positive effect on the student's learning development [7]. Also, it is necessary to include computer technologies in all curricula, because students should have the computer skills to become creators and innovators [8].

On the other hand, it is a strategy that is framed within the Information and Communication Technologies (ICT), since the implementation of augmented reality as a technological tool is very active and didactic, which facilitates the use to students, teachers and parents, encourages and provides support for learning in students, showing a better perspective of reality and objects, which will give greater precision and emphasis in the application of practice [9], [10]. However, there are limitations, among them the lack of preparation of the new technological tools to teachers, since they would not enjoy these tools in the training of students [11].

In Latin America, it is a challenge to implement such technology, since it is a new educational guide for the student's formation process [12] in science branches, including engineering. This technology is not yet applied in Peru due to lack of investment in higher education, however, with the implementation in universities, it increases the competencies of the future professional and future labor demands.

The contribution of the research is that through a pilot, courses are carried out in the faculties and then to be able to radiate to the other faculties of the university under study. Thus, the stakeholders benefit as the teaching students and the university.

Therefore, the objective of the article is to describe the application of AR in the learning process in a university in northern Lima, emphasizing a possible prototype in the University of Sciences and Humanities (UCH), in order to improve learning in the specialty of Electronic and Industrial Engineering. The main advantage of this technology for teachers and students [13] is to improve and provide a good quality education, among those involved.

It will also be demonstrated through the analysis and design of a possible prototype of the augmented reality of the mentioned specialties, these points will be fundamental for the understanding and observation of the improvement in higher education, for this reason it will be analyzed and identified research.

2 Literature review

The research work has allowed to detail the importance of the importance of the application of augmented reality in the learning process in the universities of northern lima.

According to the authors [14], indicate that the validation test also found that augmented reality technology falls into the valid category with a mean V value of 0.933. Therefore, it cannot be denied that augmented reality technology is valuable to use in the learning process.

On the other hand, the authors [15], emphasize that AR technology can be used as an alternative way of learning, especially during learning in Al Furqon kindergarten. The development of augmented reality application can be given using a studio based in Arasma, with daily learning materials for preschool students.

Similarly, the authors [16] analyzed the factors of computational thinking in the resolution of Geometry exercises after the intervention of AR applications. They concluded that students using AR applications with computational thinking successfully solve geometric problems through a geometric thinking process that includes elements of abstraction, generalization, decomposition, algorithms and debugging.

Also, the authors [17] synthesize that augmented reality is applied by detecting images or pictures, often known as markers, using smartphone cameras detecting these pre-stored markers. In the field of education, augmented reality is used to make the learning process more interesting and engaging. From the learning problem, the computer network is introduced into a normal trans-mediated network device.

The authors [18], discuss that the Learning Toolkit integrated into the Unite AR application that allows users to complete a specific task using augmented reality and provides feedback to educators in the form of its educational innovation integration technology to increase student engagement [2].

According to the authors [19], they provide an environment designed specifically for the needs and requirements of students. Therefore, they aim to present the importance of technological tools, emphasizing the value and effectiveness of their use in learning. They also emphasize that many teaching and learning tools integrate current technologies that enable students to acquire new knowledge, thus increasing the effectiveness of learning.

On the other hand, the authors [20], [21] emphasize the contribution of pedagogy to more effective science teaching in preschool children and to learning and understanding through digital programs. Therefore, they intend to develop an intervention program to test whether technological tools improve learning in preschool children. They also experimented by forming 2 groups of children. A control group and another experimental group. Since the result was that digital media facilitate the teaching and learning of students.

Also, the authors [22] emphasize that augmented reality is an emerging technology that has penetrated into different areas of life including education and specifically the teaching-learning process at different levels of study and research topics. And as a result, they obtained that student say that using AR helps them to better understand the concepts of quadratic surfaces, more so during the COVID19 pandemic, when education is largely measured by ICT.

The authors [23], show the use of AR to help students represent, create networks, visualize 3D shape structure, and measure surface area and geometric mass in 3D integrated AR in 6E I3DGM.

Finally, the author [24] proposed the “AR Globe” project to demonstrate students’ attitudes towards the integration of AR content into existing learning environments that could enhance students’ VAK learning styles.

In conclusion, a literature review of the different research works related to the application of augmented reality in learning has been carried out, in order to take into account some points. Since the authors have raised different objectives with their respective methodologies, so that they can achieve their results. The research gap is that in the educational sector the authors who investigated in this line are more oriented to primary education but very little in higher education. That gap between college and university AR study needs to narrow. In addition, it can be said that the problem is the part of the budget that educational institutions manage for emerging technologies such as AR.

3 Methodology

This article was dividing the methodology into two phases or observation points in order to know the results of the use of AR, at present and how this technology could be applied in university education.

3.1 Analysis

In many courses that derive from science and engineering there are difficulties in learning, this is due to the fact that most of them analyze 3D objects [25]. The UCH, has several courses depending on the specialty and the cycle, specialties such as Electronic Engineering with mention in Telecommunications and Industrial Engineering, have courses where the AR could be implemented for the benefit of student learning, in Table 1 shows the courses where you can apply the prototype of the AR, this prototype can be used not only as an alternative for teaching students but also for workshops or conferences that are given at the university in the future [26].

Table 1. Courses where they could be implemented

University of Science and Humanities courses			
Cycle	Specialty	Course	Topic
I	Engineering Industrial	General Chemistry	Quantum theory, photoelectric effect and atomic spectra.
IX	Electronic Engineering with mention in Telecommunications	Microwave and satellite communications	Satellite coverage and orbit concepts

3.2 Design

Flow chart functionality. The operation of AR consists of four fundamental steps, capturing the real environment, identifying patterns and elements, real scene plus augmented reality [27], visualizing the scene plus magnification. As shown in the flow chart in Figure 1 made in Bizagi Modeler.

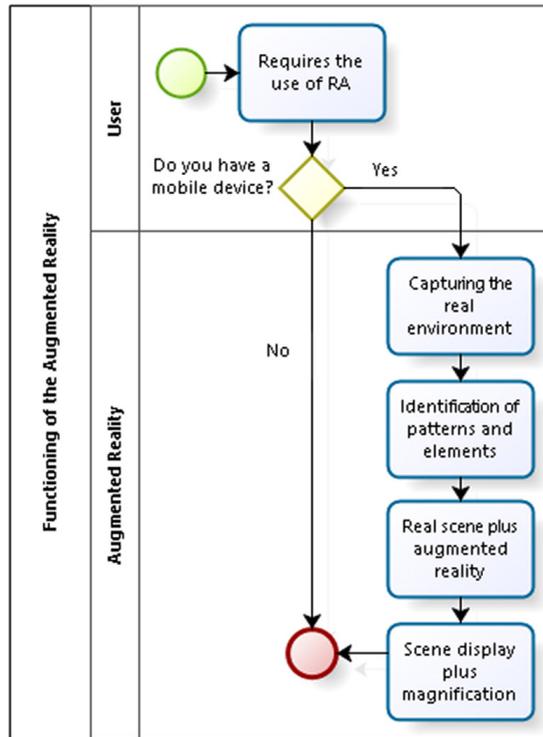


Fig. 1. Functionality of augmented reality

Use case. For the development of the prototypes the diagram of cases of use of the AR was realized, the process is around two actors, the student and teacher, it begins with the capture of the image, mapping of patterns, load of content, it mixes with the mixed reality and it finishes with the presentation of the content of the AR [28], for it the teacher stores in the database content of education, as it is shown in Figure 2.

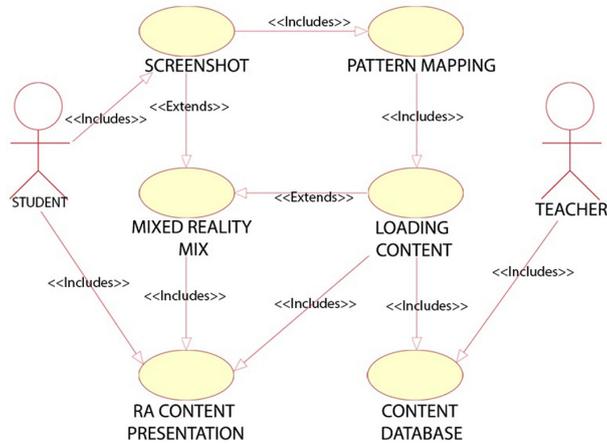


Fig. 2. Use cases of the AR functionality prototype

Prototype application interface. The prototype of the AR application is based on the interaction of university stakeholders with students and teachers, starting with the scanning of QR codes from an image. As shown in Figure 3.

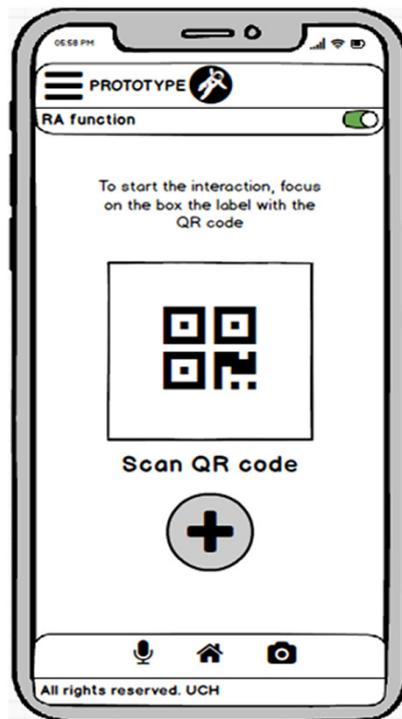


Fig. 3. UCH QR code prototype interface

3.3 Programming language and database

The use of the AR learning prototype at UCH is required: First, train teachers, describing the benefits of AR as a teaching support material for successful teaching and learning.

Vuforia. Vuforia framework will be used for the development of the application since it provides application programming interfaces (API).

Programming language. Use of C++, Java, Objective-C. The SDK is compatible with the development for iOS and Android, allowing the development of RA applications easy to transport to both platforms [29].

Database. The DB SQLite database manager will also be used because of its speed of response; the database will be of the relational type.

4 Results

4.1 About the case study

As a sample of the prototype, two pilot classes was set up, taking it to a classroom, where it was done gradually or in small periods of time depending on the type of class being taught. The investigation was carried out by selecting the most feasible courses for the pilot test. These courses were decided by experienced teachers in the subjects under study. In each semester more courses with AR will be incorporated but gradually. For this, a detailed plan has been made for the realization of the educational project for 3 consecutive years. On the other hand, for its use, the teacher will place in printed sheets the QR codes according to the type of images he wants to implement within the real space or surface, as shown in the interface in Figure 4.



Fig. 4. AR application interface on the UCH

Figure 5, shows the interface of the chemistry class, in the subject of quantum theory, photoelectric effect and atomic spectra. For this, the processes that have to be taken into account are also proposed, such as the didactics of teaching in the chemistry syllabus and the way in which students can intervene and the way that learning is effective and efficient.



Fig. 5. Chemistry class interface

For the interface of the Microwave and Satellite Communications class in the topic of Coverage Concepts and Satellite Orbits, the explanation of satellite orbits is shown in Figure 6. In this case, planning for the class session is required; In addition, in what way is the class more impressive? For this, a brief survey of class satisfaction and continuous improvement is proposed.



Fig. 6. Microwave interface and satellite communications satellite orbits

Also shown in Figure 7, the explanation of the conceptualization of coverage of the course of microwave and satellite communications.



Fig. 7. Microwave interface and satellite communications coverage concept

In this pilot class session, it is carried out with the purpose of being able to achieve the objectives of the class unit. It serves as a complement to the theory carried out in class. In this way we can affirm the importance of classes using theory and practice; where the practice is done with the AR in microwaves.

4.2 About the survey

In order to understand the impact of the AR prototype proposal at UCH, it is important to know the students' opinion. For this purpose, a first survey was conducted among 22 students where six questions were asked about AR and its use in higher education, as shown in Figure 8, "NO" predominates as an answer to the question about AR knowledge, while the result indicates a high interest in its use in university education.

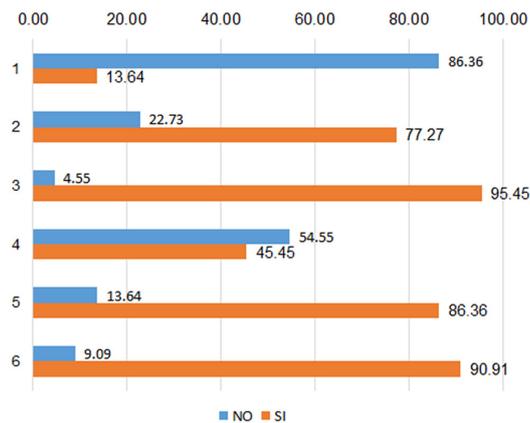


Fig. 8. Augmented reality survey graphs

In Figure 9, it shows as a result a high interest, after showing the prototype of the application of the incorporation of augmented reality in the courses of specialties of electronic and industrial engineering of the UCH.

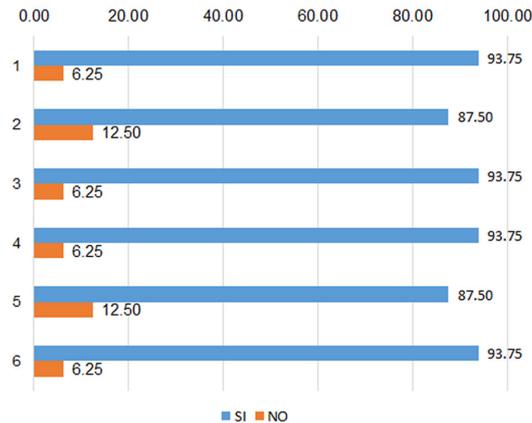


Fig. 9. Survey charts on the augmented reality prototype

5 Discussions

Los hallazgos encontrados en la investigación son similares a lo realizado por el autor [2], ya que en su investigación realizaron simulación de sus diseños. En ese sentido concuerdan que la simulación fue realizada como una prueba piloto en un primer momento, luego se iban mejorando haciendo la retroalimentación. En ambos hubo satisfacción por parte de los estudiantes y cambios de mentalidad de sus autoridades. Además, los autores [20], [21] realizaron sus estudios de una forma experimental teniendo 2 grupos en estudio, uno de control y el otro experimental, a diferencia del trabajo de investigación no fue experimental, pero en ambos estudios la finalidad es mejorar el proceso de la enseñanza aprendizaje mediante uso de tecnologías emergentes como la AR.

This project can be replicated in the different disciplines by selecting which courses are the most appropriate to apply augmented reality in their study program. after selection they can start first with a pilot test. It is recommended that an analysis be carried out which courses have the characteristics or criteria for the applicability of augmented reality. Then they should do a simulation of the design and prototype made. The contribution is for the university and therefore those involved as students and teachers. This contribution is through the technological trends that the faculties of the UCH must have.

6 Conclusions

With the pilot proposal, it was possible to convince the authorities and teachers that with the use of AR the teaching-learning process can be improved in the different courses of the curriculum. The prototype shown by means of a simulation in the

distance modality, it was demonstrated that the AR allows to interact between students and teachers in the most effective and efficient way, arousing the interest of the students. It is important to train students and teachers on the new technological tools that involve three-dimensional images permanently, in order to have a quality education. A limitation that was found at the beginning was that teachers and some authorities wanted to continue with traditional education and not go to the use of AR. Also, it can be affirmed that the contribution of the research. was to lay the theoretical foundations in the procedure for carrying out the AR to apply it in the other courses. It is suggested to irradiate all the study programs of the careers, selecting the courses by programs. In addition, as future work, the study of the research must be carried out in a multidisciplinary way, with experts in computer science, electronics, among others.

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