Use of Augmented Reality AR in University Environments

Javier Sánchez Guerrero, Javier Salazar Mera, Wilma Gavilanes López,
Rina Sánchez Reinoso, and Cristhian Tamami Dávila
Facultad de Ciencias Humanas y de la Educación
Universidad Técnica de Ambato
Ambato, Ecuador
{jsanchez,javiers,wilmalgavilanesl,rk.sanchez,ctamami}@uta.edu.ec

***Abstract*—This research fulfills the objective of using a trend considered Emerging Technology called Augmented Reality (AR) to measure the perception of learning of students in Nursing School of the Technical University of Ambato, in the subject of Anatomy and to use it in the area of the skeletal system. The population of this study was 70 students from third to fifth semester with the use of a Booklet with RA and mobile devices, which was subsequently assessed according to the Technology Acceptance Model (TAM). The results found showed high fullfillment in the use of educational texts with RA, for the interactive contents that aroused the interest and motivation in the subject, furthermore there was an improvement in the learning process. Finally, it was also possible to reach the conclusion that the use of RA in education raises the students' perception, decreases learning time in the subject viewed, which leads to look at other areas in a future work that contributes to university education.**

***Index Terms*—Augmented reality, anatomy, mobile devices, teaching, learning.**

I. Introduction

In higher education institutions, alternatives have been created that allows improvement of learning skills in different areas; one of the alternatives is the use of Augmented Reality in learning Human Anatomy. Augmented Reality RA is defined as a technology that covers elements created on a computer in real time, in two or three dimensions and whose vision is possible through an electronic device with a camera and internet connection [1].

The present work uses RA in mobile devices which, combined with educational texts with QR codes for university students, allowed to manage a topic in Human Anatomy for 6 weeks. The particular topic of Human Anatomy was learning the Skeletal System. The total population that participated was 70 students from third to fifth semester in Nursing School of the Technical University of Ambato, conducting an experimental field research.

According to a pre-test, it was determined that the students do not recognize the different parts of the skeletal system easily, due to the traditionalism of the material used, which provided room for the creation of material with RA, its application in the population of study and again the application of the test to measure the dominance in the knowledge acquired.

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The objective of the present work was to determine the perceptions that nursing students showed, regarding the design, ease of use, perceived usefulness and attitude towards the use of the contents presented with RA using mobile devices in the subject of Anatomy, for which the TAM Technology Acceptance model was used.

II. State of the Art

The term RA is not so new, it has been used for many years, the first prototype was designed by [2], to build a synthetic environment through visualization, using a device mounted on the head (Head Mounted), later in the 1990s, the term augmented reality was originated by Boeing aircraft manufacturing scientists and since then several prototypes have been created that have improved with the progress of science [3], being defined as a technology that allows the interaction of users with the real world through computer-generated objects and augmented information, displayed on images, videos, 2D text, 3D, in real time [1].

At present, both hardware and software technologies allow RA applications to be very easy to use, being accessible and available to the vast majority of users, especially in the educational field, in a recent study proposed by [4], on the educational use of geolocation and RA applications in high school, undergraduate programs and professional training in Spain, conclude that more than 80 percent of students have available devices with Android operating system, and more than 60 percent of those devices have integrated GPS, allowing to work with geolocation applications with RA.

A. Technologies that use Augmented Reality

As explained by authors such as [5], [6], there are different technologies that are necessary to produce RA environments and are as follows:

1) A device that captures the image that users are seeing: it can be a computer monitor, a telephone, videoplayer, or a tablet;
2) A device that projects the mixture of the real images with the synthesized images, same devices mentioned above
3) A processing device or several, that work together to interpret the real-world information that the user

receives, when generating the virtual information that each specific service needs and mix it appropriately (computers, mobiles or videoplayers);
4) A type of specific software for the production of the program;
5) An augmented reality activator or markers that can be QL codes, physical objects, GPS, ...);
6) A content server where the virtual information that we want to incorporate into reality is located.

According to [7], to present the contents of RA, three types are presented:

1) QR codes. The interaction is perceived by two-dimensional codes of square shape, in which alphanumeric information can be stored, to visualize it, a QR code reader installed in a mobile device is necessary, and it is through this device that the information is presented.
2) Placeholders. The process consists in associating a 3D image, a video or animation to a printed marker using specific software, when passing the marker through the webcam the virtual layer contained in it will be activated.
3) Geolocation. This involves the integration of RA, GPS, visual search systems (CVS) and mapping (SLAM) technologies. These applications offer the user a framework of interaction with the urban system from its location at a certain point, which is visualized through the camera of the mobile device, the user obtains the physical image of the place and an overlay of virtual layers of information shown in real time, information about nearby establishments, history of the environment, events, among others, for its creation, there are different programs and applications: layar app, Junaio, Wikitude, Metaio, Hoppala, and Layar.

In recent years there have been many researches and applications on Augmented Reality, in which the educational possibilities are analyzed, including the presentation of interactive contents and improvements in academic performance [8]–[10], the components of RA, such as videos and 3D images, can help students understand abstract content in a better way [11], visualizing them through mobile devices, this being more satisfactory than the traditional classes in the classroom [12].

The experiences on the integration of RA in the educational processes are present in different fields, from medicine [12], architecture and urbanism [12], mathematics and geometry [13], language learning [10], art and history [14].

B. Educational Experiences with Augmented Reality

Among the most relevant applications designed with RA, there are 3 large groups which are Didactic Books, Games, and Object Models with RA. Without a doubt, Magic Book [21], perhaps is one of the best known applications of Augmented Reality in education; a project of the active group HIT of New Zealand, the student reads a real book through a manual visualizer and observes pages with virtual content, elements that grow with sensorial stimuli generated by the computer, such as sound, video , graphics or GPS data.

With regard to the games, the Massachusetts Institute of Technology (MIT) and the Harvard research group are in the process of creating educational programs with RA applications in game format for high school students, which combine real-world experiences with additional information shown on their mobile devices. Games have also been developed to teach math and science subjects and all of them are oriented to work collaboratively among students [22].

The experiences on the inclusion of the RA in the educational processes are present in different disciplines, from medicine [23], architecture and urbanism [24], mathematics and geometry [25], foreign language [26], art and history [27].

In what corresponds to object modeling, it has been developed in educational processes and are present in different disciplines, from medicine [12], architecture and urbanism [24], mathematics and geometry [13].

The work of [28], which contributed to an analysis of the effects of RA on school performance, in learning mathematics in informal environments in Vaduz, Liechtenstein in the year 2015, concluding that the group of students using material with RA learned significantly compared to the group that used traditional material, emphasizing that it was a field experiment using mathematics exhibition. The students perceived RA technology as a valuable complement to the exhibition to better understand the proposed contents.

In Argentina there are some experiences of integration of RA to educational processes. It can be mentioned ”EPRA (in Spanish): Tool for the Teaching of Basic Concepts of Programming using Augmented Reality”, that in the field of teaching programming have allowed to contribute to the motivation of the first-year students majoring in programs in the Faculty of Computing of the UNLP in 2015. This application aims to involve the student with new concepts relating to their basic knowledge and reality; it is applied by teachers and students with great acceptance [29] .

Also mentioned is the ARERE Project (Augmented Reality Environment for Remote Education), an interactive and collaborative system based on RA, which was included in a distance learning system where professors teach using RA in order to improve communication processes making them more natural through distance [30].

On the other hand [31], evaluated the impact of mobile RA in the teaching-learning process of university students in the area of medicine, through a survey on the main learning factors as well as related aspects of pedagogical design, digital , student-centered design, self-regulation and usability aspects; carried through with control groups and applying pre-test and post-test, to know the impact on learning, arriving to conclude that the mobile application of RA has a high degree of acceptance in the students achieving significant results in learning.

From the various studies mentioned, it can be pointed out that the application of resources with RA facilitates, motivates and makes it more interesting the explanation and

assimilation of the contents, generating a better interaction between teachers and students, this way, fulfilling one of the objectives of the learning process, which is to induce interest in self-learning, research and collaborative work.

RA is a technology that offers some advantages in the cognitive process in education, which have been cited in [32].

- It encourages the development of cognitive, spatial, perceptual motor and temporal skills in students, regardless of their age and academic level.
- It promotes the development of attention and concentration of short-term memory and long-term memory, in its visual and auditory forms, as well as reasoning.
- It helps the activation of cognitive processes of learning, encouraging the active participation of the student.
- It promotes the formation of reflective attitudes when explaining observed phenomena or providing solutions to specific problems.
- It fosters an effective communication environment for educational work, because it decreases the uncertainty of knowledge of an object.
- It increases the positive attitude of the students before learning, as well as their motivation and interest in the subject that is being addressed, reinforcing capacities and competencies (independence, initiative and principle of self-activity or independent work).

As evidenced, there have been many advantages in education with the application of resources with RA, but it can also be mentioned the difficulties encountered, according to other studies by several authors, [33] wich mentions the difficulty of use on the part of the students, requirements for more reading and use time; also [34] talks about the low sensitivity of recognition, [35] details on expensive technological resources, [36] ergonomic problems, [37] difficulties in design.

Therefore, it is necessary to consider some elements of hardware, software and pedagogical conditions to plan a didactic experience that allows integrating RA technology in the classroom, including:

- Availability and accessibility of technological resources.
- Educational material.
- The target group with which you work.
- The type of RA that you want to use (recognition by markers or by geo-positioning).
- Methodology for design and application.

Despite all these requirements, RA technology has been inserted easily and timely in education. It has been used especially to present abstract content, perform laboratory experiments without risk, reduce costs and use available resources by students for this to take effect.

However, the current state of research on RA in education is still in its infancy [15], despite the many investigations carried out, much remains to be done about the study of this emergent technology in education, considering its possibilities and its difficulties, its integration in the pedagogical processes through a methodology that facilitates the role of both the teacher and the student in the daily field of education.

III. Methodology

In this research, the experimental field methodology was used within the subject of Anatomy in Nursing School, with students of Third, Fourth and Fifth semesters, representing a total of 70, which 13% are men and 87% are women This sample represents 23% of all students in Nursing School.

In the study, the survey was used as a technique with questions focused on the variables of the augmented reality study and the teaching-learning process.

Figure 1 shows the process that was followed in the design of resources with RA, it was necessary to review the cognitive contents proposed in the Anatomy syllabus, the teacher specialized in the subject selected the chapter corresponding to the axial skeleton, considering it of high relevance, with images that need to be seen in three dimensions. In order for these resources to be used by the students, a printed didactic booklet was designed and handed at the beginning of the course.

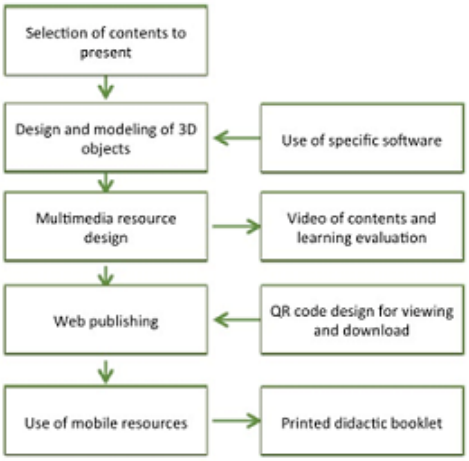

Fig. 1. Process for the design of resources with augmented reality

The resources that are used in the Anatomy laboratory are real bones, appropriate for the manipulation of students, there are 19 pieces. 3D objects were designed with the bones that correspond to the axial skeleton using Autocad 2017 [14] which is a technical drawing software suitable for the construction of objects that can be viewed from different angles up to 360 grades. Table 1 presents part of the inventory of 3D objects designed for the present study.

3D images are uploaded to the Augment repository, which is a free App for both Android systems and IOs [16], the QR code is automatically generated and downloaded as a marker, meaning, images framed in a box [17] the same ones that are located in the printed and when viewed by the camera of the mobile source, it interprets them, allowing to visualize the content. The brochure proposes 14 didactic contents with videos, 3D images and interactive evaluations, each subject has RA markers, in Table 2 the structure of the brochure is described.

The QR codes are classified by colors, the black color represents the images in three dimensions, the red color is for

Fig. 2. Graphical structure of the QR codes

TABLE I
3D OBJECTS INVENTORY

N	Description
1	Spine
2	Ribs
3	Coccyx
4	Skull
5	Normal intervertebral disc
6	Human Skeleton
7	Breastbone
8	Fontanelles at the time of bird
9	Cranial bones Frontal Bone
10	Cranial bones occipital bone
11	Cranial bones Parietal bones
12	Jaw
13	Paranasal sinuses
14	Chest/Thorax
15	Cervical Vertebrae

the videos for being associated to YouTube and the green color is for the evaluations. The use of the didactic brochure with the nursing students of the Technical University of Ambato, 9 men and 61 women, was done during 10 hours of class, with the guidance of the tutor of the subject of Anatomy. The students had mobile devices with an Android or IOS operating system and a QR code reader installed on them. In Figures 3 and 4 you can see the visualization that is achieved by passing the mobile application on the QR code of the Booklet, giving a 3D image that can be rotated up to 360°.

TABLE II
BROCHURE CONTENT OUTLINE

Initial pages	Content
Presentation	Subject
Index	Objetive
	Develeopment
	QR Codes
	3D Images
	Didactic video content
	Online autoevaluation

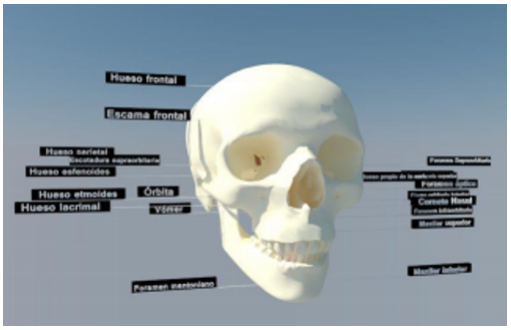

Fig. 3. Image of the skull viewed with RA

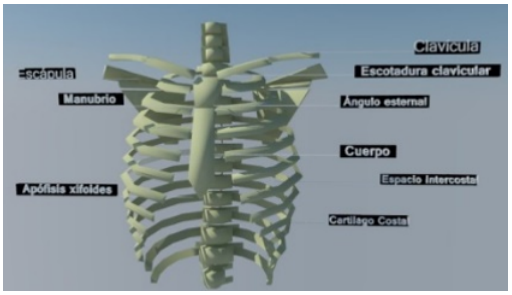

Fig. 4. Image of the chest viewed with RA

Students value their work experience with RA, responding to the questionnaire prepared based on the Technology Acceptance Model TAM [18], [19], which examines the determining categories to encourage the use of a digital material in education and how it relates to each other, this model argues that the acceptance of a technology for the learning process is influenced by the beliefs and attitudes of its users [20].

IV. RESULTS

The questionnaire used has a total of 12 items that allowed to determine the students' perception in regards to 4 categories: design, ease of use, usefulness and attitude towards the use of content with RA.

The Design category refers to the way in which the contents are presented. It obtained excellent results in the application of multimedia tools (see figure 5). For this category, 4 questions were considered that denote the relevance in the design of 3D images, videos and navigation, which is directly related to the didactic of the Anatomy subject.

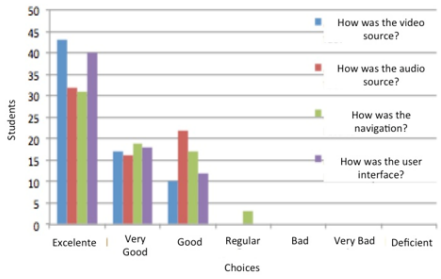

Fig. 5. Didactic brochure design

For the Ease of Use category, we worked with 3 reagents, which made it possible to demonstrate the comfortability in the management of resources such as mobile, cellular and ipods selection and reading QR codes for the visualization of 3D images, as well as access to the proposed evaluations (see figure 6).

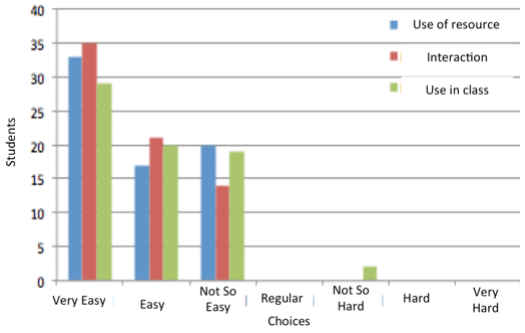

Fig. 6. Ease of use of the didactic brochure

When the Perceived Usefulness of the model was analyzed, 2 items were considered (see figure 7). It is appreciated that the students agree that the benefits of the tools are directly correlated with the work done in classes as well as in the development of activities that must be performed outside.

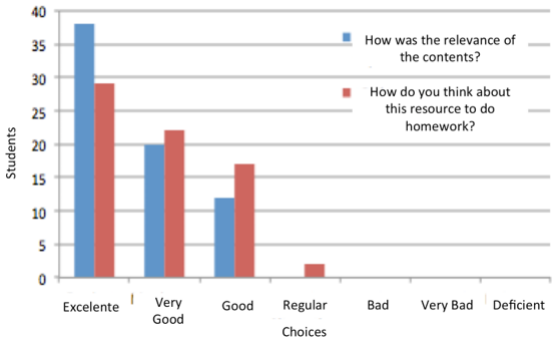

Fig. 7. Image of the chest viewed with RA

Regarding the Attitude towards the use of the didactic booklet with RA, it could be determined that the students like the way the class is taught (see figure 8), because the material provided is very easy to use and is also motivating and innovative.

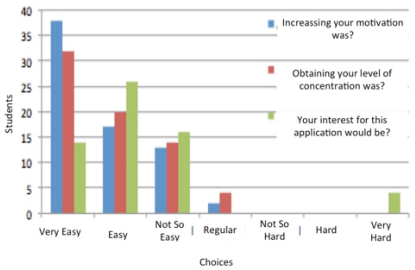

Fig. 8. Attitude of use of the didactic book

A knowledge test was performed before using the augmented reality software and manual, to seventy students of Nursing School, the results are reported as Note 1; After a month, a second evaluation was done with the same students, after they had already met and worked with the RA manual and software, the results are reported as Test 2.

In Fig. 9 the pre and posttest notes are shown in the sequence: pretest of the recognition of the skeletal system, application of the Booklet created with RA, and finally a new evaluation with the post test.

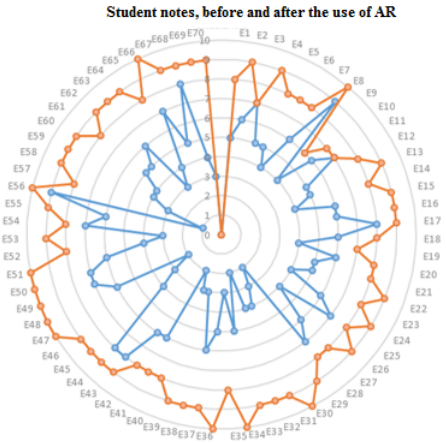

Fig. 9. Pretest and postest

V. Conclusions

In a study on the evaluation of the student's attitude towards learning in augmented reality environments using a system of marks [20], they concluded that these resources provide extra motivation to learn; likewise in this study a favorable attitude is noticeable in the use of the didactic brochure with RA, for the ease of use of the resources and their usefulness in the educational process.

The 4 dimensions consulted had a very high degree of responses that are directly interrelated, the ease of use with the perceived utility, which generates an attitude of use that is in direct agreement with the design of the didactic brochure, that includes text, images , videos and evaluations, incorporating as an innovative element the use of marks that allow viewing content overlayed on digital images to show information.

The Anatomical didactic brochure was widely accepted for the ease of observing bones of the Axial Skeleton in 3D format approaching reality, facilitating the understanding of the contents by applying technology as an innovative entity for the interaction between the user and the three-dimensional resources presented. In this booklet students were able to access multimedia content, use of virtual 3D objects and the understanding of real objects, fostering a transformative educational experience.

This study yields comparable results with a large part of the work done by different authors that express that students feel motivated when they interact with objects constructed with

RA and show high levels of satisfaction during the interaction with them [39]–[45].

The didactic booklet is directly oriented to the needs of the students of Anatomy, since both the design and the selection of the contents were validated and tested by experts in the subject, the work was done with the students' own devices and no difficulties of interaction and understanding of its management was presented, the interaction and motivation was highly satisfactory, due to the combination of pedagogy and technology, making classes dynamic and entertaining.

It was evidenced that the categories consulted are directly related to each other and that the perceptions that the students showed regarding the design, the ease of use and the usefulness of the contents presented with RA using mobile devices in the class of Anatomy were highly satisfactory.

The limitations in applying RA in the subject of Anatomy would be related to issues in connectivity, availability of mobile devices, and administration by the teacher. The research that can be done would focus on the implementation in other subjects and new content to determine its impact on higher education educational processes.

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