Towards the Development of Emotions through the Use of Augmented Reality for the Improvement of Teaching-Learning Processes

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***Abstract*—This research aims to determine how the use of Augmented Reality technology propiciates learning achievements through generate emotions in students. The metodology used for development of this research was the selection and application of ARToolKit open-source software, specialized in augmented reality implementation, after that, we implemented a 3D model on the topic "Cell Biology" developed in "Unity3D". A Likert scale test according to main emotions is applied to a sample of 50 students selected through simple random sampling from a total population of 100 students. The sample is divided into two groups, 25 students for the experimental group and 25 students for the control group. In experimental group, Augmented Reality will be used during three learning sessions. In control group Augmented Reality is not used. In both cases the Likert scale test will be applied after each learning session. At the end of the three learning sessions, a competency-based evaluation is applied according to selected criteria. The results show that 80% of the 25 students in the experimental group improved their academic performance with respect to the control group, which maintained a standard average academic performance of 50%. In conclusion, we can say that the use of Augmented Reality technology in the development of sessions in teaching-learning process, generate emotions in students who are enable to improve their learnings.**

***Index Terms*—Augmented, emotions, e-learning, learning, reality, teaching.**

I. Introduction

The value of this research lies the in the use of Augmented Reality technology in teaching-learning process, allows the students to elect the contents to work in, increasing their autonomy for learning and makes viable self - evaluation based on this app and increases the competence capacity when they achieve each objective in the proposed activities.

Thus, this learning system offers interactivity and their essential parts provides interaction between sense of sight, sense of hearing and sense of touch, in addition to improve students' attention and a better understanding of the contents and the concepts in learning process. At present, the use of AR Technology is closer to teachers more than ever before. A few years ago, it was not possible to imagine this technology simplified at its complexity and usability to be used in classrooms by teachers and students or even to create their own content.

There is an interaction between emotions and learning, but this interaction is more complex than all the past educational theories have could articulated. The Augmented Reality technology is one of 21st century emerging technologies, which has several applications in daily life [1]. In the educational environment the Augmented Reality Technology would fit perfectly like a support tool in students training using emotions [2]. Being that, there is no learning without emotion. According to [3] "You only learn what you love, therefore it is essential to know the world of emotions to capture the essence of teaching". At the same time, Augmented Reality technology is one of the best ways to make a connection between the real and digital world, stimulating, in that way the emotions, this feature would complement and reinforce students learning with educational content. Likewise, Natural Sciences field needs a tool with the characteristics mentioned above. In the same context, [4] states the following: "Teaching science involves to increase a constant interaction between reality and knowledge, not only through theory but also by conducting experiments that suggest questions based on scientific reasoning". In this way, the use of Augmented Reality in education can influence positively, in the emotions, for the achievement of learning objectives in Natural Sciences field. Likewise, "student motivation is a critical variable for science teaching." [5], Certainly, we can say that attitudes and expectations of students about the scholar duties, affect their learning achievements. Augmented Reality has the ability to transform the sensory perception of the real world, adding inventions based on virtual reality, generating mixed models of reality, which overcome the limits of the real world, making complex or abstract phenomena and elements, much more perceptible [6].

According to [7], Augmented Reality is based on the superimposition of virtual information on physical spaces in real time, through digital devices. Transforming, in this way, an interaction between the real world and digital resources, influencing the perception of people making them believe that the real and the unreal world are blended in a same place.

So augmented reality could be defined as that additional information obtained from the observation of an environment, captured through the camera of a device that previously has a specific software installed. In agreement with [8] supported by [9] there are 4 levels of augmented reality, which are

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detailed below:

- Level 0: Hyperlinks in the physical world. Hyper applications link the physical world through using barcodes and 2D codes (e.g., QR codes). These codes only can serve as hyperlinks to other content, so there is not 3D registration.
- Level 1: Marker-based augmented reality. Applications use markers, black-and-white, quadrangular, schematically drawn images, usually for 2D pattern recognition. The most advanced form of this level also allows 3D object recognition.
- Level 2: No Marker augmented reality. Applications replace the use of markers with the GPS and compass of mobile devices to determine the user's location and orientation and overlap points of interest to the real-world images.
- Level 3: Augmented Vision. It would be represented by devices such as Google Glass, high-tech contact lenses or others that, in the future, will be able to offer a fully contextualized, immersive, and personal experience.

Projects involving Augmented Reality have been developed [10] such as the ARToolKit project that is based on a library, developed by Hirokazu in 1992 and published by the HIT Lab at the University of Washington, that makes possible augmented reality with virtual images or animations overlapping the real world.

It is currently an open-source project. The Augment project is an AR Platform that allows the visualization of images or 3D models in the real-world environment, in real time and on a large scale. It is the most widely model used in education in large universities. The EON Reality project, which consists of an interactive Digital Center with the purpose of producing virtual and augmented reality content and also to train future professionals, its projects cover different areas of knowledge, for example: Howard Carter's journey in the Valley of the Kings, Egypt.

According to [11] "Almost everyone thinks they know what an emotion is until they try to define it. At that point, virtually no one claims to be able to understand it." It is difficult to give a specific concept to emotions since they can be related to various terms such as feelings. However [12] gives a possible definition "an emotion could be defined as an affective experience at certain point pleasant or unpleasant, that involves a characteristic phenomenological quality and engages three response systems: cognitive-subjective, behavioral-expressive and physiological-adaptive". An emotion like an elementary, is a common character in the human species, for these authors basic emotions facilitate a functional response to an event in daily life [13]. [14] distinguishes six basic emotions of human beings: Surprise, as a result of an unexpected or unforeseen event; Sadness, grief, discouragement, or disappointment; Fear, perception of danger; disgust, strong dislike and disgust; happiness, had reached a desired goal; and anger, rage, fury and violence.

“Educational processes are ultimately conceived as processes of emotional scaffolding." [15]. This is how emotions become capital in the development of learning, however, there is a lack of attention to the emotions of students during educational processes in the twentieth century [16]. It should be noted that the work done by [17], relating emotion and the power of educational processes, proposes that emotions are built based on experiences.

The teaching of a science such as Biology needs a constant interaction between reality and knowledge and not only by concepts but also through experimentation that makes students to formulate questions based on scientific reasoning [4]. All this must been seeing since a didactic perspective for this reason [18] demands the use of "active methodologies" which encourage inquiry in science fields. Because of that, it is very necessary counting with interaction environments for learning development and for a good classroom climate, a good example of interaction between the theory and the students are the technological resources such as the augmented reality [19]. In addition, motivation is considered as a critical variable for science teaching as it is related to students’ attitudes and expectations, together with "active methodologies", represent the method to get closer the science and the students [5]. Thus, Augmented Reality becomes an indispensable tool for science teaching, supporting student motivation and being complementary in an innovative methodology for learning achievements

Emotions induced by augmented reality are positive for the acquisition of new knowledge [20]-[22]. According to, [19] state that Augmented Reality, is able to transform the sensory perception of the real world, thus counting with virtual reality models that overcome the limitations of physical and abstract representation in our world. "According to the perception of students learning with educational objects with augmented reality is a positive, pleasant and rewarding emotional experience." [20]. This relationship has been verified by the work of [15], where a greater presence and variety of positive emotions for learning was detected. In addition, it is suggested to "turn on" the emotion first, through the use of methodologies and resources that provoke the student's curiosity about what he/she wants to learn [3], [22]. This is important according to [23]: "When a student acquires new knowledge, the emotional and cognitive parts operate in an interrelated way in his/her brain. Moreover, emotion acts as a guide to the acquisition of that learning, so that it labels experiences as positive and therefore attractive to learn or as negative, therefore likely to be avoided" [2].

In a cafe, in a journey or while you are driving a car, radio may be a good choice, however no one watches a radio on Internet these days when they have a chance of watching a TV channel. Virtual Radio Centers, including access to several radio channels and compatible with mobile phones should be more common in future. These centers will help people to visualize what's going on and will give them a chance to participate both physically and virtually. Nonetheless, a Virtual Radio Center will make the sounds visible! [21].

In [22] is examines the conceptual design of AR applications as a learning activity with low technical requirements. With the help of the learning activity, the principles of AR and of the subject area can be conveyed, and the learners’ engagement with the learning content should be stimulated. In this study, Bachelor students of civil engineering ($N = 71$) have been assigned the task of an AR application for the subject domain of technical infrastructures, such as traffic management or energy supply.

The students describe the design of the AR application with an own photo shot of the technical infrastructure with the augmentation on the photo and an explanatory text of 100–200 words. Combined these three elements serve as an illustration, which is made available to fellow students in an online gallery for peer review by means of a questionnaire. The peer review is intended both to examine the quality of the contributions—and thus possible learning outcomes among the submitters—and to stimulate the reviewers to engage with AR and the subject domain. A subsequent survey evaluates the students' assessment of learning success. Although the study only suggests actual learning outcomes of the learning activity, it demonstrates how complex technologies, such as AR, can be integrated into learning contexts with low technical requirements [24].

The research answers the question what extent does the use of augmented reality promote the achievement of learning through the development of students' emotions?

II. Methodology Developed

A. Research Objective

To determine to what extent the use of augmented reality favors the achievement of learning through the generation of students' emotions.

B. Research Hypothesis

The use of augmented reality is conducive to the achievement of learning through the generation of students' emotions.

C. Research Variables

Independent Variable: Application of Augmented Reality.

Dependent Variable: Achievement of learning through emotions.

Controlled Variables: Number of students with whom we will work using Augmented Reality and Time Regulation.

D. Population and Sample

The population is constituted by 100 students, from which through a simple random sampling 50 students were chosen, where each element of the population has the same probability of being selected to be part of the sample [25]. The sample is divided into two groups: Experimental and Control Group. As shown in Table I.

TABLE I: Group Experimental and Control Groups

Study population	N ° of Students	N ° of Males	N ° of Females
Group A: Experimental	25	10	15
Group B: Control	25	12	13
Total	50	22	28

E. Academic Context

The research will be developed in the biology course, in students of Secondary Education of Regular Basic Education.

F. Methodological Design

The methodological design followed is shown in Table II.

TABLE II: Methodological Design for Groups A and B

Group	Tool used	Assessment of learning	Likert scale test	Duration
Group A: Experimental	Augmented Reality is used in the learning sessions developed.	The same evaluation will be given to both groups.	A test based on the Likert scale will be applied in different dimensions of the learning sessions.	3 weeks
Group B: Control	Augmented Reality is not used in the learning sessions developed.			3 weeks

G. Procedure

- Selection of the software "ARToolKit, open-source software specialized in the implementation of Augmented Reality.
- Implement a 3D model on the topic "Cell Biology" developed in "Unity3D".
- To train the teacher in charge of case "A" on the use of Augmented Reality.
- To elaborate a Likert scale test according to the main emotions.
- In the Experimental Group, Augmented Reality will be used during three learning sessions, unlike the Control Group, which will not use this tool; however, in both cases the Likert scale test will be applied after each learning session.
- At the end of the three learning sessions, a competency-based evaluation will be applied according to selected criteria.
- The data obtained will be collected for subsequent analysis and interpretation.
- A Likert scale satisfaction test has been implemented according to the following dimensions: Topic Substantiation Dimension, Use of Tools for Learning Dimension, Satisfaction before Assessment Dimension, Satisfaction after Assessment Dimension, and Topic Conclusion and Self-Assessment Dimension.

H. Data Collection Instruments

The data collection instruments are shown in Table III.

TABLE III: Data Collection Instruments

Instrument	Activities	Details
Test	The Likert scale test is applied to measure the students' satisfaction after the learning sessions.	Test that measures a user's opinion about a specific topic.
Evaluation	The achievements obtained with and without the use of Augmented Reality are evaluated.	It is measured according to the average scores of each case for later analysis.

III. Analysis and Interpretation of Results

Table IV shows the results by dimensions of satisfaction degree of students in the Experimental Group according to the

Likert scale test applied.

TABLE IV: DEGREE OF STUDENT SATISFACTION BY DIMENSIONS IN THE EXPERIMENTAL GROUP

Dimensions	N °of Students	Average
Topic Rationale	25 students	4.21
Use of Learning Tools		4.59
Satisfaction before the Evaluation		3.97
Satisfaction after the Evaluation		4.03
Topic Conclusion and Self-Assessment		4.51

Table V shows the results by dimensions of satisfaction degree of students in the Control Group where Augmented Reality is not used in the learning sessions.

The method used to measure the dimensions in Table IV consisted of the application of 25 items, 5 items for each of the 5 dimensions; from the lowest satisfaction degree 1 to the highest satisfaction degree 5. In this study, the Likert scale is used to validate the students' evaluations, where: 1=strongly disagree, 2=disagree, 3=neither disagree nor agree, 4=agree and 5=strongly agree. This in turn allows us to obtain a very structured and transparent evaluation process at the moment of obtaining the students' opinions.

TABLE V: DEGREE OF STUDENT SATISFACTION BY DIMENSIONS IN THE CONTROL GROUP

Dimensions	N °of Students	Average
Topic Rationale	25 students	3.56
Use of Learning Tools		3.53
Satisfaction before the Evaluation		3.40
Satisfaction after the Evaluation		3.39
Topic Conclusion and Self-Assessment		3.81

The following is a comparative analysis of the results of the degree of satisfaction by dimensions established in the Experimental Group and the control group.

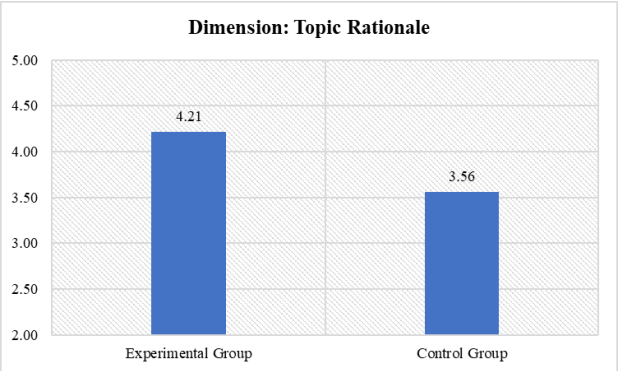

Fig. 1. Dimension: Topic rationale.

In Fig. 1, can be noticed that satisfaction emotions presented by the Experimental Group are greater than those that belong to Control Group; the students of the experimental group were "Satisfied" with the dimension of the foundation of the subject and the Control Group only managed to feel "Neither Satisfied, Nor Dissatisfied". The difference is large between these two groups. Why does this wide difference in satisfaction occur? According to [26], the use of new technologies generates an environment of social interaction where new knowledge is demanded or generated. Which means that the students of the Experimental Group have generated learning, due to social environment that also generates emotions. The school is an apparently neutral educational system; however, the school reproduces, as [27] would say, "a demanding social structure that executes power, is violent and makes social equality impossible. These facts, of course, favor the generation of certain emotional states at the collective level, so that the pedagogical actions of this social space make students feel valuable or worthless".

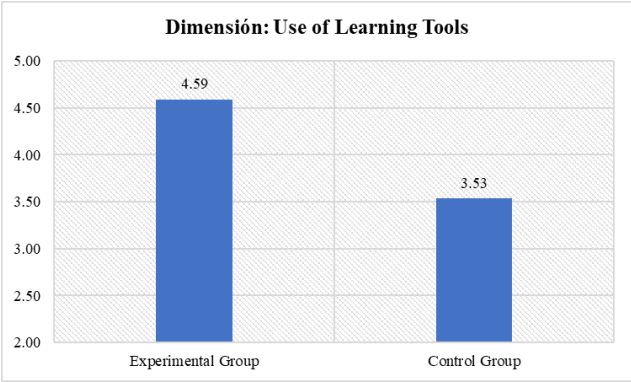

Fig. 2. Dimension: Use of learning tools.

According to Fig. 2, in the dimension: Use of learning tools, the Experimental Group has advantage over the control group. This dimension measures the degree of acceptance of the students in the use of Augmented Reality that generates more emotions. According to [28], Augmented Reality presents different functionalities for information processing, access to knowledge, communication channels, social interaction environments, etc., besides being a new technology among students, it somehow attracts their attention.

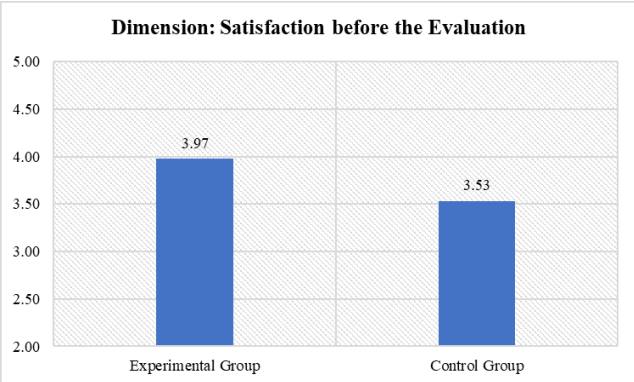

Fig. 3. Dimension: Satisfaction before the evaluation.

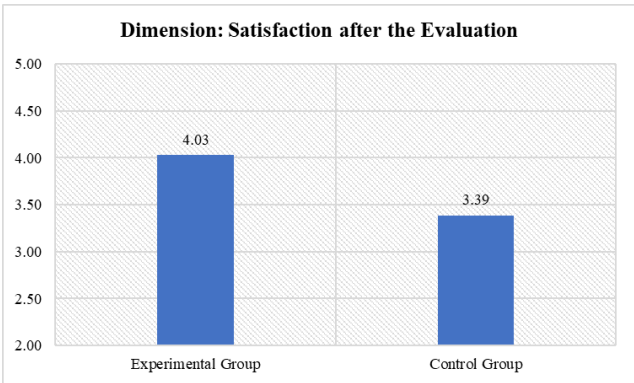

Fig. 4. Dimension: Satisfaction after the evaluation.

According to Fig. 3, it is observed that in the dimension: Satisfaction before evaluation, the experimental group

presents greater satisfaction. According to [29]. Since the students could feel anxiety, i.e., "that may simply be a previous experience of blocking an exam, or have been unable to remember known answers".

According to Fig. 4, this dimension shows the superiority of the Experimental Group over the Control Group. When feeling "Satisfied" the Experimental group, it means that their grades in terms of academic performance are satisfactory.

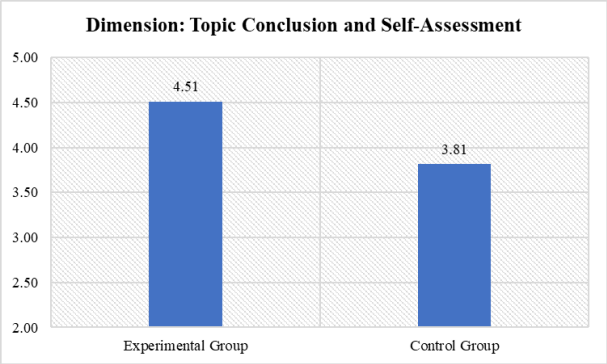

Fig. 5. Dimension: Topic conclusion and self-assessment.

In Fig. 5, it is observed that the students of Experimental Group are more satisfied with development of Learning Session, because of the feelings they generated during the learning session, so we can conclude that the Experimental group had generated more emotions than the control group.

A. Comparative Analysis according to Learning Achievements

The knowledge and understanding acquired by students are then measured through an assessment that includes items with indicators for the achievement of skills such as: Mastery of concepts, to Select and apply relevant information and concepts, to demonstrate strong problem-solving competence, to develop detailed explanations of complex phenomena, and to communicate in a good manner, using appropriate terms.

TABLE VI: EXPERIMENTAL GROUP CRITERIA RATINGS

Dimensions	N °of Students	Average
Concept mastery	25 Students	3.31
Selects and applies relevant information and concepts		3.19
Demonstrates strong problem-solving competence		3.37
Develops detailed explanations of complex phenomena		3.28
Communicates in a good manner and with appropriate terms		3.55

Table VI presents the results of grades of students in experimental group according to the criteria taken.

TABLE VII: RATINGS BY CONTROL GROUP CRITERIA

Dimensions	N °of Students	Average
Concept mastery	25 Students	2.77
Selects and applies relevant information and concepts		2.89
Demonstrates strong problem-solving competence		2.96
Develops detailed explanations of complex phenomena		3.17
Communicates in a good manner and with appropriate terms		3.27

Table VII presents the results of grades of students in control group according to the criteria taken. This is followed by an analysis for each learning criterion:

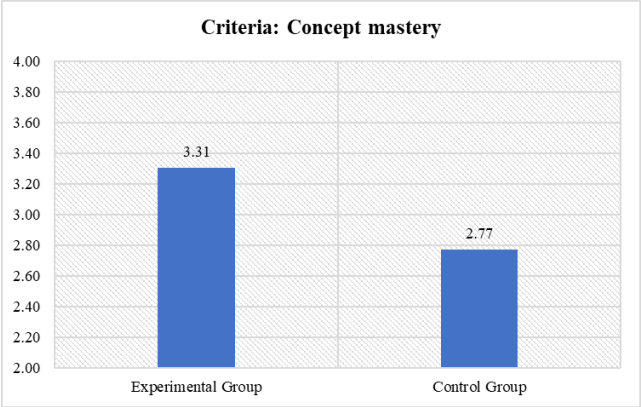

Fig. 6. Criteria: Concept mastery.

According to Fig. 6, the Experimental Group presents high scores in the Concept Mastery criterion compared to the control group. This is due to the implementation of Augmented Reality. This group has more mastery of concepts, while in the traditional way of teaching there is not much motivation to develop this ability in the students.

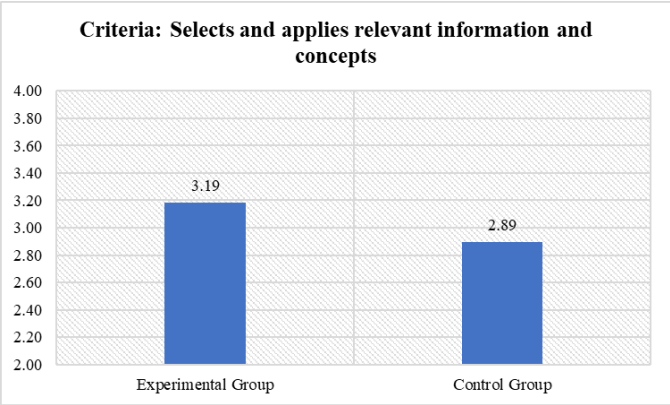

Fig. 7. Criteria: Selects and applies relevant information and concepts.

In Fig. 7, a significant improvement is noted in the experimental group compared with the control group in the evaluation of the criterion select and apply relevant information and concepts.

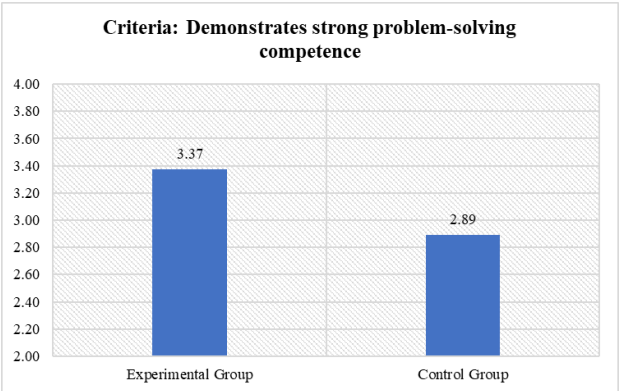

Fig. 8. Criteria: Demonstrates strong problem-solving competence.

According to Fig. 8, the Experimental Group shows better scores in the criterion: Demonstrates competencies to solve problems. This criterion evaluates how the student uses his

knowledge to solve a problem.

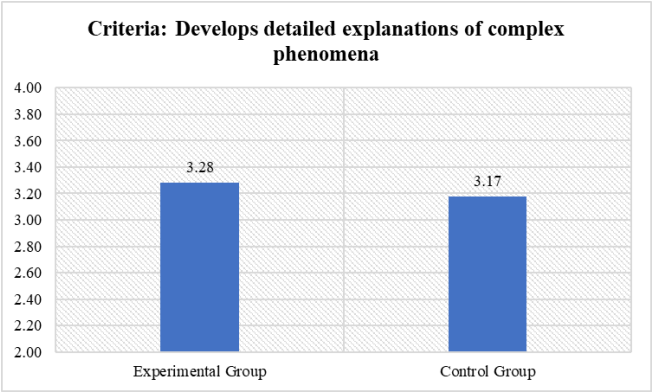

Fig. 9. Criteria: Develops detailed explanations of complex phenomena.

According to Fig. 9, in the dimension: Elaborate detailed explanations of complex phenomena, the superiority of the experimental group is notorious. This is due to the fact that through the use of augmented reality in the teaching-learning processes, the phenomena are explained in detail.

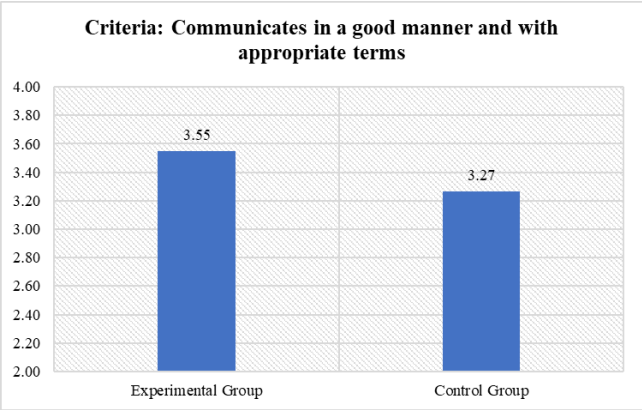

Fig. 10. Criteria: Communicates in a good manner and with appropriate terms.

Fig. 10, in the criterion: Communicates in a good way and with appropriate terms, the experimental group was more attentive and noticed to the terms, unlike the control group that was not so excited and did not pay attention to the development of the session.

B. Comparative Analysis of Results between the Experimental and Control Groups

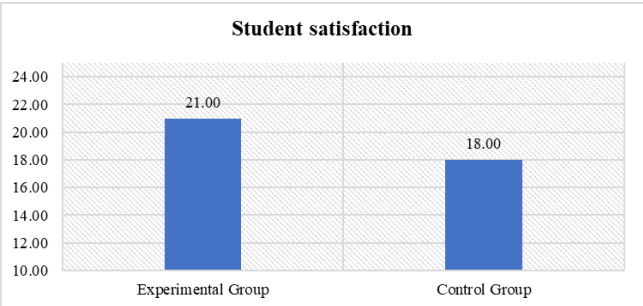

Fig. 11. Student satisfaction between experimental and control groups.

According to Fig. 11, it can be seen how students in the Experimental Group had generated more emotions than the Control Group.

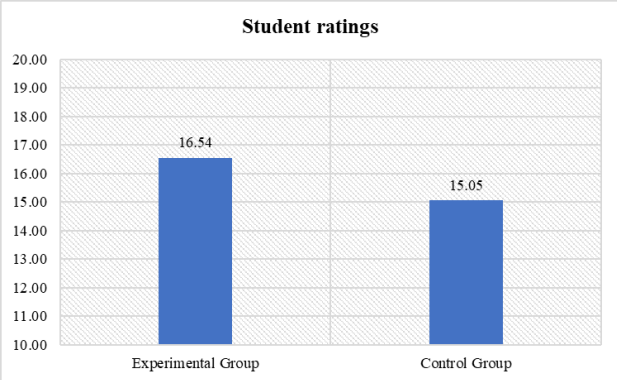

Fig. 12. Student ratings between experimental and control groups.

According to Fig. 12, it can be observed that the students' scores are higher due to the emotions generated by the Experimental Group.

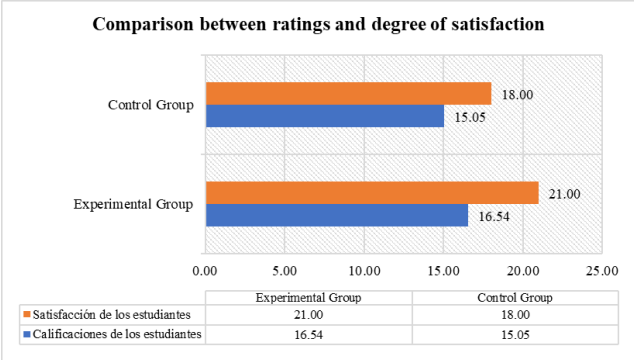

Fig. 13. Comparison between the knowledge and understanding acquired and the degree of satisfaction.

Fig. 13 shows the superior academic performance of the experimental group compared with the control group, likewise with respect to the satisfaction degree also shows a higher satisfaction in the experimental group with respect to the control group, demonstrating the influence of the use of augmented reality in the teaching-learning processes.

C. Degree of Covariation between Student Emotions and Learning Achievement

Pearson's correlation, which aims to measure the strength or degree of association between two quantitative random variables that have a joint bivariate normal distribution, is applied [26]. This correlation will be applied to results of each session to verify that the emotions are affecting the grades and continue with the comparison of these ones. As shown in Table VIII

TABLE VIII: PEARSON CORRELATION TO MEASURE THE DEGREE OF ASSOCIATION BETWEEN VARIABLES

$r = 1$	Perfect positive correlation
$0 < r < 1$	Positive correlation
$r = 0$	No linear relationship
$-1 < r < 0$	Negative correlation
$r = -1$	Perfect negative correlation

Table IX shows that the result is greater than zero, but less than one, so the variables have a positive correlation, that is, they are related. This helps me to prove that emotions are indeed affecting learning achievement. After the application of Pearson for each group, these are the results:

TABLE IX: RESULTS OBTAINED FROM PEARSON'S CORRELATION

Pearson Applied to Experimental Group	0.84902469
Pearson Applied to Control Group	0.68240902

IV. DISCUSSION OF THE RESULTS

The motivational element, very important in education, seems to be guaranteed; numerous researches have suggested that Augmented Reality reinforces learning and increases motivation to learn [30]. The use of Augmented Reality in teaching-learning processes influences positively in developing student's emotions; promoting the achievement of learning. These emotions are important for establishing positive interpersonal relationships as supported by [23]. In addition to awakening students' curiosity, encouraging them to use the technology by themselves. According to [31] emotions can vary even more if working with adolescents, because adolescents have sudden mood swings, causing a deep depression or overflowing anger and even boredom with this technology, what would cause conflicts. As students belong to the digital era, it is easier for them to handle technologies, as long as they assume their responsibility as digital citizens. In addition, they should be encouraged to create their own tools with the knowledge learned. Students feel a wide range of emotions that can have intense effects on their learning, personality development and health. The effects of these emotions could be complex. Positive emotions do not always benefit learning, and unpleasant emotions do not always make impossible to learn. However, for the vast majority of students and academic learning tasks, enjoyment of learning is beneficial, whereas anxiety, embarrassment, hopelessness, and boredom are detrimental [32]. Which is confirmed through this research developed; students who develop emotions in the sessions improve their learning.

V. CONCLUSIONS

The use of Augmented Reality in the development of sessions in the teaching-learning process generates emotions in students that enable them to improve their learning, as could be seen in the results of the 25 students in the experimental group, 80% improved their academic performance compared to the control group, which maintained a standard average of 50% in terms of academic performance.

About the results of satisfaction, which was developed through the standardized Likert test of emotions, it shows that as the students generates more positive emotions, as they are more encouraged for the learning sessions and therefore their academic performance improves considerably, meanwhile the students in the control group were not so excited to develop the learning sessions in a traditional way. This can be confirmed according to the results of the evaluations, where their academic performance remained below average.

For the vast majority of students, academic learning tasks, enjoyment of learning is beneficial, while anxiety, embarrassment, hopelessness and boredom are detrimental. Moreover, emotions are fundamental elements of students' identity and well-being, implying that emotions are a fundamental element of students' identity and well-being, so emotions are also important, beyond their functions for academic learning. For all these reasons, educators should pay attention to students' emotions.

There are several ways to help students increase positive emotions and decrease negative emotions. Most importantly, educators can help students to develop self-confidence, interest, and intrinsic value that promote enthusiasm for learning and decrease negative emotions. This can be done by providing high-quality instruction, using one's own positive emotions as a teacher, creating mastery goal structures in the classroom, employing mastery standards to inform students about their learning progress, avoiding high-stakes testing, involving parents, and caring for the classroom. In addition, teachers can contribute to the achievement of educational goals related to emotions by helping to organize schools and educational systems in an emotionally appropriate way.

Technology through the use of Augmented Reality in teaching-learning processes becomes a support tool to achieve educational objectives [30], [33].

The generation of augmented reality in the research is implemented with two specific free access applications ARToolKit and Unity 3D, limited to the development of emotions, through the development of teaching-learning sessions; however, for future development of the research it is recommended to use more sophisticated augmented reality applications.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest in relation to the research carried out.

AUTHOR CONTRIBUTIONS

Benjamín Maraza-Quispe implemented the methodological design, Olga Alejandro-Oviedo reviewed the background, Kelly Llanos-Talavera performed the statistical analysis, Walter Choquehuanca-Quispe analyzed the data, Simón Choquehuayta-Palomino implemented the discussion and Nicolás Caytuiro-Silva contributed the conclusions and recommendations.

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