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# A didactic sequence design for the use of augmented reality in the teaching process of the human body in elementary education

# Diseño de una secuencia didáctica para la utilización de la realidad aumentada en el proceso de enseñanza del cuerpo humano en educación primaria

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**Abstract**

The following research evaluates the impact on 4th grade elementary school students´ meaningful learning through the design and implementation of a didactic sequence that includes the use of augmented reality applications in order to teach about the circulatory, respiratory and digestive systems. Such didactic sequence was designed over the content of the SEP free text books, including as an augmented reality tool the application called Arloon Anatomy. The results obtained through statistical tests, U de Mann-Whitney and Wilcoxon, show that the impact is positive in the teaching-learning process, finding that the use of Augmented Reality aroused interest and stimulated the desire to learn motivating students to be more proactive, increased the level of attention and fostered an investigative spirit through the discovery of the functioning of the human body.

**Augmented Reality, meaningful learning and didactic sequence**

**Resumen**

En la presente investigación se evalúa el impacto en el aprendizaje significativo de los estudiantes del cuarto grado de primaria, a través del diseño e implementación de una secuencia didáctica para incluir el uso de aplicaciones de Realidad Aumentada para la enseñanza de los aparatos circulatorio, respiratorio y digestivo. La secuencia didáctica fue diseñada con base a los contenidos de los libros de texto gratuitos de la SEP, incluyendo como herramienta de realidad aumentada la aplicación Arloon Anatomy. Los resultados obtenidos a través de pruebas estadísticas, U de Mann-Whitney y Wilcoxon muestran que el impacto es positivo en el proceso de enseñanza - aprendizaje, encontrando que el uso de la Realidad Aumentada despertó el interés y estimuló las ganas de aprender motivando a los alumnos a ser más participativos, aumentó el nivel de atención y fomentó un espíritu investigador a través del descubrimiento del funcionamiento del cuerpo humano.

**Realidad Aumentada, aprendizaje significativo y secuencia didáctica**

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## Introduction

Technological progress took off at the end of the 20th century and in the 21st century it has become part of people's daily routine, in such a way that technology has revolutionised the way of doing things even in areas where it was difficult to imagine that it could be useful, education is no exception; many teachers have started to use it as a support tool to motivate or diversify the teaching-learning process. This is the case of augmented reality technology, which since its inception has been seen with good eyes and accepted by some institutions to the extent of having it as a support tool. In this sense, augmented reality currently represents a powerful tool that has shown its versatility in a wide range of applications in different areas of knowledge. In the field of education, it has found great possibilities for the dissemination and knowledge of content that is presented in an attractive and pedagogical way at the same time (Ruiz, 2011).

In Mexico, there are many primary education institutions that are reluctant to use ICT (Information and Communication Technologies) as a support strategy for the diversification of content delivery, due to many factors ranging from infrastructure, access to technology and lack of digital skills among teachers (Díaz-Barriga, 2010).

The use of technology provides an opportunity to generate new teaching strategies that are in line with reality, since most of the thematic content is disconnected from reality or the context in which students develop. A clear example is Chiapas, which ranks as the state with the highest rate of educational backwardness, due to the fact that 13.7% of the population aged 15 and over are illiterate, 10.5% of the population between 6 and 14 years old do not attend school and 48.1% of the population aged 15 and over do not attend school. 1% of the population aged 15 and over have incomplete basic education (Consejo Nacional de Evaluación de la Política de Desarrollo Social [CONEVAL], 2021), so the quality of education is poor compared to other states; in addition, there is a large digital divide and a fragmented teachers' union, with resistance to change and to proposing new teaching-learning strategies. (Pacheco, 2015)

The above represents a problem of learning where this is reflected as a margin of memorising without deepening or internalising the content, therefore, there is a need to link teaching-learning strategies mediated by the use of ICT, specifically Augmented Reality, presenting a great opportunity to make use of it, being a tool of great interest and of great impact today, providing information from the real world and interspersing it with the digital world. The great boom of mobile devices has helped many technological tools to be included as support in the teaching-learning process, because they do not have many limitations and access to resources can be too intuitive, as stated by Estebanell (2012) "AR applications not only respond to this type of requirement but extend it in a qualitatively significant way by providing information located, contextualised, from the place and at the time that the consumer needs it" (p. 290).

The relationship between ICT and education is more than evident, several studies point out that technology will continue with or without us, future generations will be increasingly related to technology "so orienting its use and exploitation to educational processes from a proactive perspective helps the application and improvement of the pedagogical elements of the present and the future" (Angarita, 2019, p. 144).

## Theoretical framework

### Augmented Reality in education

In recent years, Augmented Reality has been widely used and is becoming increasingly relevant in various areas of knowledge, thus demonstrating that it is a versatile tool that offers a wide range of possibilities.

In this sense, Orozco, Esteban and Trefftz (2006) define Augmented Reality (AR) as a technology capable of complementing perception and interaction with the real world, providing the user with a real scenario, augmented with additional information generated by computers (pp.141-145).

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It should be noted that within the academic world, the most widely accepted definition of Augmented Reality is that of Azuma (1997), who defines it as "the technology that allows the real and the virtual to coexist in the same space, giving the possibility of interacting with these elements in real time" (pp. 73-272). Although this definition is many years old, it still retains the essence, although clearly, in recent years, new functionalities have been added both to interact and to connect. This is due to the great evolution of mobile devices that are nowadays known as Smartphones.

On the other hand, Badia et al. (2016) indicate that the use of Augmented Reality in education has had a great impact and this is due to the great evolution of technology and the information society, which have allowed for a large number of didactic resources. In his research entitled "The perception of the usefulness of technology shapes its use for teaching and learning" he found how the use of this technology as a support tool helped to improve the teaching-learning process.

Another research by Toledo and Sanchez (2017) defined this technology as an opportunity in the acquisition of knowledge and an option to improve performance, proving to be desirable and beneficial. However, it is worth mentioning that they found limitations, in that some subjects do not fit the content with what they have in the application and this limits its use.

The biggest challenge in using this technology lies in the digital competences of teachers, since they are the ones who must change the new teaching approach; as indicated by Toledo and Sánchez (2017), a teacher with digital competences can make the teaching-learning process more effective; however, training to acquire digital competences in teachers and the application of these in the teaching and learning process has been left to the Mexican government, implementing digital education programmes from 1997 to 2016, but without knowing the impact they have had on student learning. (Silva, 2021).

**Significant learning**

Ponce (2004) states that "meaningful learning requires students to carry out various activities to establish relationships between what is new and what they already know" (p. 22), i.e., they must know how to reformulate, differentiate, discover, order, classify, hierarchise, relate, integrate, solve problems and understand a text. In order to achieve a great educational task and achieve meaningful learning, it is necessary to take into consideration three elements of the educational process: the teachers and their way of teaching, the structure of the knowledge that makes up the curriculum and the way in which it is produced, and the social framework in which the educational process takes place. (Sansevero, Lúquez and Fernández. 2006. p. 279).

According to the theory put forward by Ausubel (1973, 1976 and 2002), which is still valid today, student learning depends on the previous cognitive structure that is related to the new information, understanding cognitive structure as the set of concepts and ideas that an individual possesses in a certain field of knowledge, as well as its organisation. In this sense, this type of learning plays a very important role for teachers and students, and even with the didactic material used to transmit this knowledge.

Larios and Rodríguez (2011) state that knowledge must be organised in a logical structure in such a way that its elements are related to each other. But the logical structure of knowledge is not enough; it is also necessary that the person shows a predisposition for learning and is motivated. This is a great challenge because the main enemies of learning can be textbooks, the number of students, the timetable, a very tight curriculum, teachers limited to change the didactic sequence and the fear of change. (Albornoz, 2009)

**Didactic planning**

Planning is a requirement that is imposed on a daily basis in every activity carried out by human beings. "Teaching work does not escape this requirement, especially if we take into account the moral and social consequences that it implies" (García and Valencia, 2014. P. 15).

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The Ministry of Public Education defines didactic planning as the organisation of a set of ideas and activities that will make it possible to develop an educational process. It constitutes a model or pattern that allows teachers to face their practice in an orderly and congruent manner (SEP, 2009). It involves analysing and organising thematic content, determining the objectives, intentions and educational purposes to be achieved, as well as establishing the sequence of activities in time and space.

Teaching practice is determined by the teaching-learning actions that take place in learning environments, and didactic planning is a tool that teachers must use to make these actions effective. (Islas et al. 2014). In this sense, a good planning of the strategies, techniques and resources that will support the classroom to achieve the objectives, skills and competences will allow the teacher to achieve the expected results.

Lule (2003), in his research, points out that teaching practice is made up of various teaching-learning activities that must be carried out in the classroom, which must be in accordance with the thematic content of the curriculum.

Therefore, it is essential for teachers to design a didactic sequence that allows them to organise activities for students to acquire their learning (Lozada, 2018). The didactic sequence should be designed taking into account the objectives to be achieved in the subjects, through activities that allow them to be contextualised and that generate meaningful learning in students, as well as including ICT to contextualise those scenarios that cannot be contextualised on a daily basis in the classroom. (Domínguez et al. 2020).

## Objective

The present research project aims to design and implement a didactic sequence for the teaching of natural sciences through the use of augmented reality, in order to strengthen meaningful learning in fourth grade federal primary school students. In this way, the research project is justified because it helps to formulate new proposals for innovation and diversification in teaching-learning strategies, through the design of didactic sequences mediated with the support of ICT.

The project will establish a pedagogical proposal that will be very useful for educational institutions.

## Methodology

This research project worked under a quantitative approach, which is characterised by privileging empirical-deductive logic, based on rigorous procedures, experimental methods and the use of statistical data collection techniques (Barrantes, 2014).

The methodological approach was under a descriptive quasi-experimental design, having a sample of three groups from different federal schools, obtaining the study sample was non-probabilistic and intentional; we worked with students from three different schools that met the selection criteria of the lowest, middle and highest academic performance of the 2018-2019 school year, having a single control group and an experimental group, where tests (test) designed for the study and diary of the researcher were applied.

The tests (pre-test and post-test) were designed with dichotomous questions, attached to the contents of the topics that were addressed in the intervention of the study, its reliability was verified through the KR20 test with the SPSS statistical software, obtaining a value of 0.862, being a Very High reliability coefficient according to Ruíz (2013).

The participants in the study were 107 students in the 4th grade of federal primary education in the municipality of Ocosingo, Chiapas. There were also three regular teachers, who were present only as observers during the interventions. The age of the students ranged between 9 and 10, and in total there were 80 females and 47 males. The control group used a traditional teaching method and the experimental group used the didactic sequence with activities related to the circulatory, respiratory and digestive systems, with the inclusion of the augmented reality tool.

## Pedagogical proposal

In order to design the pedagogical proposal, the following phases were considered (Figure 1): Selection of the subject and topics that would be related to the free textbooks of the chosen school grade.

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Choice of the augmented reality tool attached to the chosen topics; Design of the intervention through the didactic sequence of learning, with the activities to be developed by the teacher and the students, in order to generate meaningful learning; Implementation of the Insitu intervention, according to the designed didactic sequence; Providing feedback on the results obtained from the study to the authorities of each selected primary school.

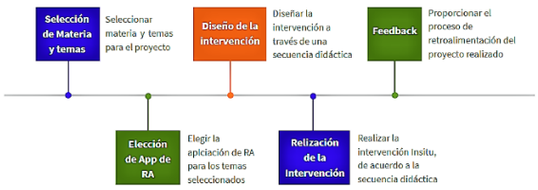


**Figure 1** Implementation phases of the pedagogical proposal
*Source: Own elaboration*

*Phase 1. Selecting the subject matter and topics for the project*

In this phase, the contents of the free textbooks provided by the SEP were analysed in order to select those topics that are difficult to contextualise in the classroom. For this reason, the subject of Natural Sciences and the topics of the functioning of the circulatory, respiratory and digestive systems in the fourth grade of primary school were selected, so that these topics would not remain theoretical and could be interacted with more realistically with the help of an augmented reality tool.

*Phase 2. Choice of the augmented reality tool*

This phase was carried out at the same time as the choice of subject matter and themes, and the criteria used were usability, licence and usefulness. As we worked with children, we selected the Arloon Anatomy application (Figure 2), which is easy to use and does not cost a lot to purchase, and it visualises the topics chosen for the subject, so that the students could interact and learn how the parts of the human body work.


**Figure 2** Arloon Anatomy application
*Source: Research Images, 2020*

*Phase 3. Design of the intervention through a didactic sequence*

In this phase, the didactic sequence was designed for the implementation of the intervention in the experimental group (Figure 3), Díaz-Barriga (2013) proposes three types of activities: opening, development and closing, as well as activities for evaluation and feedback of the activities, therefore, the didactic sequence implemented was designed based on these activities indicated by the author, for each selected topic.


SECUENCIAS DE APRENDIZAJE:

OBJETIVO:

SECUENCIAS DE APRENDIZAJE:

| Sesión y duración | Contenidos | Actividades | Tiempo | Recursos y material didáctico | Productos |
|---|---|---|---|---|---|
| | | | | | |

| EVALUACIÓN: | |
|---|---|
| Actividades | Porcentaje |
| Total del Curso: | 100% |

| REQUERIMIENTOS PARA LA INSTRUMENTACIÓN DEL CURSO: |
|---|
| |

| Fuentes de información |
|---|
| • |

**Figure 3** Didactic sequence format
*Source: Own elaboration, based on Díaz-Barriga (2013)*

*Opening activities*

An ice-breaking activity was carried out, as it was the first time that the group of researchers had contact with the group. The next activity consisted of applying the pre-test to the experimental group to assess the level of prior knowledge they had about the topic to be taught, in addition, the same pre-test was applied to the control group, in order to compare the results and measure significant learning through the didactic sequence designed and the traditional method. It was explained to the students that the pre-test was not to give them marks or grades, but to find out the level of prior knowledge they had of the topic to be addressed that day.

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*Development activities*

An electronic presentation was made (Figure 4), in such a way that it was dynamic to develop the topic, then a video presentation was used to learn about the functioning of the apparatuses of the human body, which was in the augmented reality tool Arloon Anatomy.

Subsequently, interaction activities were carried out with the Arloon Anatomy application, where the students were divided into teams of 4 members, the group of researchers handed out a tablet and an augmented reality marker, so that the students could identify the parts of the human body of the topic that was addressed that day.

*Closing activities.*

To generate significant learning in the students, a series of knowledge exercises were carried out (identification of the parts of the body) that the application has (Figure 5), where they collaboratively answered the exercises, which were then carried out individually.

To conclude these activities, feedback on the exercises answered in the application was given by one of the teachers of the research group, in order to clarify doubts on the subject.

*Evaluation activities.*

To conclude with the topics, at the end of the intervention the post-test was applied, on the other hand, in the control group it was applied by the teacher of the group at the end of its topic in a traditional way, the above, in order to determine with the statistical test of the Mann-Whitney U, if the learning of the students was significant between both groups.

*Phase 4. Implementation of the intervention.*

In this phase, the opening, development, closing and evaluation activities, which were designed in the didactic sequence for each topic, were carried out.


**Figure 4** Presentation of the digestive system
*Source: Research images, 2020*

**Figure 5** Interaction with the AR application
*Source: Research Images, 2020*

*Phase 5. Feedback on the results obtained.*

Each principal of the schools selected for the study was provided with the results obtained from the study, emphasising that the results were favourable when using a didactic sequence with the help of an augmented reality tool for the teaching of Natural Sciences.

At the beginning of the present study, it was agreed with each principal of the selected schools to offer a workshop to their teachers in order to include an augmented reality tool for teaching the Solar System, through the Arloon Solar System application; however, due to the national health contingency, this activity was postponed until the conditions to carry it out exist.

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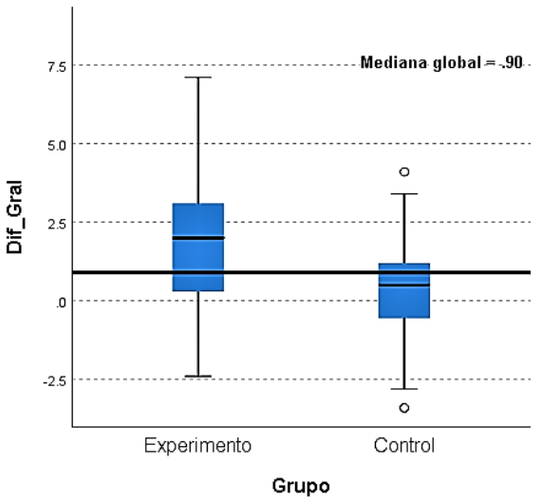
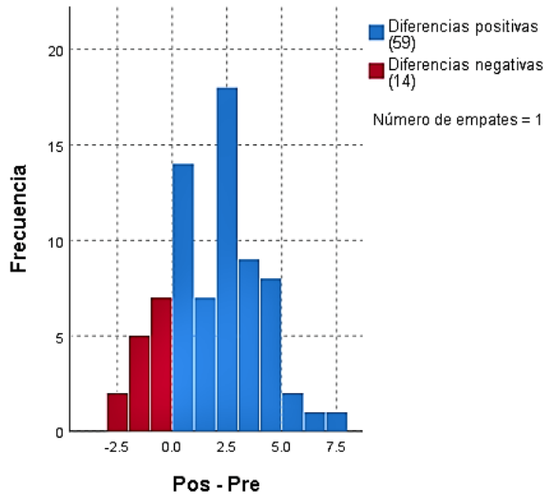
## Results

To verify whether learning was significant for the students when using a didactic sequence with the support of an augmented reality tool, using SPSS software, the Mann-Whitney U test was performed for independent samples, obtaining as a result that the p-value=0.000 is less than the established significance level α=0.05, so the results support that there is a significant difference between the two groups. In graph 1, it can be seen that in the experimental group there are more students who obtained better results after the intervention following the didactic sequence designed and with the use of the augmented reality tool.



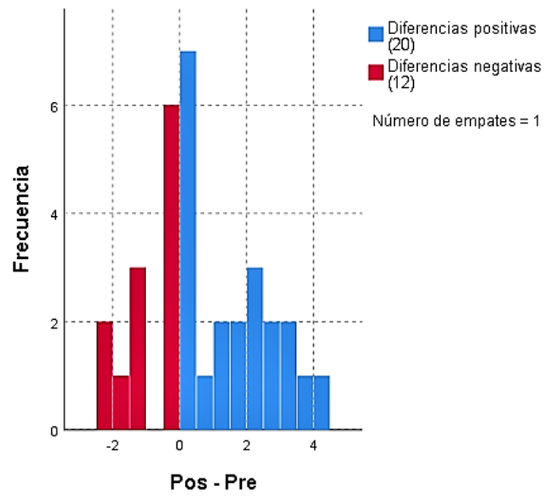

**Graphic 1** Mann-Whitney U test for independent samples
*Source: Research data, 2020*

To support the previous result, using SPSS software, the Wilcoxon test was performed between the pre-test and post-test in the experimental group, obtaining that the value of p=0.000 is less than the established significance level α=0.05, graph 2 shows that 80% of the students improved their score after the intervention.




**Graphic 2** Wilcoxon signed-rank test for related samples
*Source: Research data, 2020*

If we look at the results by school, graph 3 shows that in Cuauhtémoc school only 61% of the students improved their score after the intervention, in Marcos Villanueva school 94% (see graphic 4) and in Niños Héroes school 96% (see graphic 5), being in the latter schools where most of the students improved their score after using the augmented reality tool.




**Graphic 3** Wilcoxon signed-rank test for related samples at Cuauhtémoc school
*Source: Research data, 2020*

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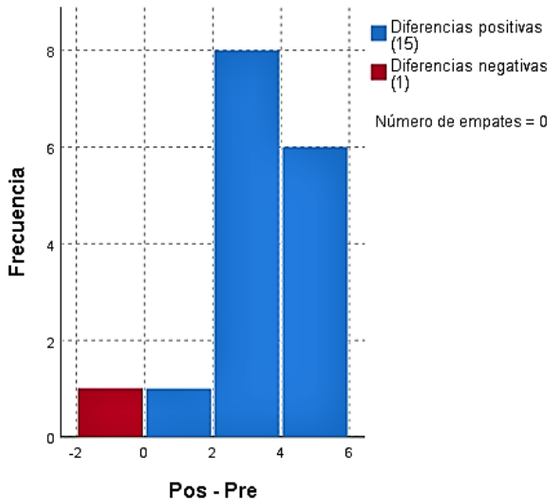
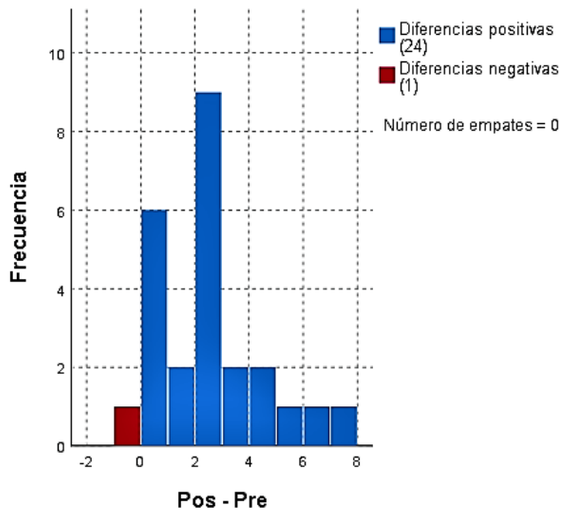



**Graphic 4** Wilcoxon signed-rank test for related samples at Marcos Villanueva school
*Source: Research data, 2020*




**Graphic 5** Wilcoxon signed-rank test for related samples at Niños Héroes school
*Source: Research data, 2020*

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We would also like to thank the directors and teachers of the primary schools, who provided us with all the facilities, spaces and resources to carry out this research project.

## Conclusions

The results obtained from statistical tests show that the design of a didactic sequence and the use of an augmented reality tool have a positive impact on the teaching-learning process, being of great value to obtain significant learning in students. It was possible to break the barrier of disconnection between theory and practice, due to the fact that, in traditional teaching, it is impossible to observe the characteristics and functioning of the circulatory, respiratory and digestive systems.

On the other hand, it is shown that a good design of a didactic sequence and the academic experience as indicated by (Larios and Rodríguez, 2011), made the use of Augmented Reality stimulate the desire to learn, arouse interest, motivate and make students more participatory, increase the level of attention and encourage a spirit of research through interaction with the AR tool, as stated by Barfild, W. and Caydel, T. (2001). and Caydel, T. (2001), and above all the learner is in the readiness to acquire knowledge as stated by Ausubel (1973, 1976 and 2002).

Finally, it was an example of how the use of Augmented Reality can represent a meaningful and motivating experience in institutional environments with limited access to technology and few digital skills.

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