



Anatomical models with augmented reality: a systematic review of their importance in the teaching of natural sciences in the context of the teacher's home.

Bolaño-truyol, jorge; brito-pinto, josé; charris-angulo, félix; conde-hernández, marcial; díaz-jiménez, arnold; fruto-silva, erick; garcía-leyva, diana; garcía-mendoza, kadry; igrío-tesillo, jader; miranda-acosta, rober; montaña-carpio, victor; rico-ballesteros, reinaldo; sánchez-montero, edgardo.

Abstract

Anatomical models, both physical and virtual, are didactic tools used in natural science education with the aim of improving learning and skills development. These models allow students to visualize and manipulate anatomical structures, which can facilitate the understanding and learning of concepts. Despite their potential benefits, the implementation of anatomical models with augmented reality (ar) can present challenges in teaching. Therefore, this systematic review aims to explore existing literature on the effectiveness of anatomical models with ar in teaching, as well as to analyze the limitations and challenges associated with their implementation. By understanding the importance and benefits of anatomical models with ar in education, it is hoped that this review will systematize current knowledge and encourage their use to improve the teaching of natural sciences.

Key words: anatomical models, augmented reality, natural sciences.

Introduction

In contemporary society, the natural sciences acquire a significant relevance in the acquisition and development of essential competencies for students, which facilitates optimal performance in specific contexts and allows them to understand the world with a solid and fundamental scientific training. The importance of the natural sciences lies in its ability to explore and explain the natural phenomena that surround us, through the application of rigorous scientific methods and the use of fundamental theories and concepts.

That is why the relevance of the natural sciences is evident in the educational framework, since they contribute to the comprehensive training of students by providing them with the tools and knowledge necessary to face the scientific and technological challenges that characterize the modern community. These essential competencies allow students to develop observational, critical analysis, and logical reasoning skills, which are critical to understanding the natural phenomena that occur around them.

The challenges in education are increasingly complex and challenging, it is essential that students develop the necessary skills and knowledge, which the sciences from their notion provide for the deep understanding of the environment and thus contribute from their knowledge to the transformation from a critical perspective and in the face of the development of cognitive skills. According to bransford, brown, and cocking (2003), in their study entitled "how people learn", they consider the way in which the human brain processes information and how this process influences learning. The authors highlight the importance of teaching natural sciences in the development of cognitive skills.

It is relevant to mention that the ministry of national education (men) in 2004, as expressed, considers scientific disciplines as units of knowledge that are deployed and deepened in theories that guide research. In this sense, disciplines such as biology and physics, to name a few, seek to describe, explain, and communicate different phenomena of reality under specific conditions. This allows us to understand and analyze what is happening in the world, as well as the underlying causes of events.

In line with the above, quintanilla (2019) points out that this process is complex and requires a rational interpretation of the data, as well as an ethical reflection on the implications of scientific discoveries.

The lack of knowledge of various didactic and technological strategies in the field of teaching natural sciences generates a conflict that affects the development of knowledge and skills of students. As a consequence, there is fragmented learning in relation to the basic foundations of this discipline, such as the living environment, the physical environment and the chemical environment. Faced with this problem, lobo, h., rosario, j. R., materán, i., pacheco, a., morón, f., and ruiz, l. (2014), in their work entitled "ict in the teaching/learning process of natural sciences", state that the use of information technologies in the teaching of natural sciences enables students to perceive and understand physical and chemical phenomena more efficiently. Unlike traditional methods, such as the use of blackboards and textbooks, icts give them the possibility to visualize concepts that were previously unimaginable. In addition, critical thinking is promoted and the development of imagination is encouraged, allowing students to delve into content more in line with their interests and preferences.

In the same vein, camargo, a. F., and méndez, l. S. A. (2021) argue in their research that, in the face of an increasingly complex and changing world, education must adapt and take advantage of the tools and technologies available to help students understand and navigate this dynamic environment. Education must be understood as a continuous process of acquisition of skills and knowledge, which allows students to develop and face the challenges that the future holds.

Undoubtedly, the purpose of the natural sciences lies in strengthening and developing the processes of scientific literacy, starting from the earliest levels of education. This leads to promoting the analysis and understanding of topics, concepts and practices that, as a whole, contribute to the development of attitudes, skills and competencies necessary in an increasingly globalized society. These approaches are supported by queiruga-dios, m. Á., lópez-iñesta, e., diez-ojeda, m., saíz-manzanares, m. C., and vázquez-dorrío, j. B. (2021), who argue that science education and citizen participation in research are fundamental elements to promote scientific competence and sustainable development. These efforts are in line with the agenda of the sustainable development goals (sdgs) declared by the United Nations (un) in 2015.

Scientific competence plays a crucial role in achieving these goals, as research, innovation and technological development are required to address global challenges and achieve the sdgs. Science is presented as a key tool for understanding natural and social systems, identifying problems, designing effective solutions, and evaluating the impact of implemented policies and practices. It is therefore essential to promote collaboration between scientists, the private sector and civil society, in order to achieve the sdgs

in a sustainable and equitable manner. Only through this cooperation can significant progress be achieved in achieving the objectives set, in line with the demands of a globalised and constantly evolving society.

It is important to highlight that the area of natural sciences contributes essential elements to the research processes that are developed from the scientific method and that these in turn have an impact on the exploration of topics, where through different innovative didactic mediations it is aimed at students identifying, exploring, discovering, explaining and communicating science, ideal scenario that will allow the training of researchers and their new learning.

That is why it is considered vital and important to intervene in the teaching and learning methods of the natural sciences, including new technologies that can enrich the experience of students in the classroom. Augmented reality is presented as a very useful tool to achieve this goal, since it allows the development of processes from inquiry in different spaces of scientific co-creation with the support of emerging mediations in order to discover and approach the reality of some events in nature. In this way, students can be trained with a critical view of the processes, and at the same time, allow to dynamize and strengthen pedagogical practices that contribute to the improvement of educational quality.

In relation to the above, the need arises to address the teacher's management of the development of competencies in the natural sciences from the didactic mediation of anatomical models. In view of what has been stated by Ausubel, D. P. (1968) ... Where he raises the importance of the acquisition of concepts and skills through the relationship between new information and previous knowledge. The author points out that anatomical models can be a valuable tool to help students acquire new concepts by relating them to the background.

It should be noted that anatomical models can be used to illustrate concepts that are difficult to understand, to illustrate spatial and functional relationships between the different structures of the body and to illustrate physiological processes and mechanisms. By using anatomical models in the teaching of natural sciences, students' visual and spatial understanding is fostered, which in turn strengthens their ability to relate concepts and apply them to real situations. As endorsed by Ordoñez Játiva, A. E., & Villagómez Antamba, A. L. (2022), the authors propose how virtual anatomical models can be used to improve student learning, pointing out that, with the growing presence of technology in education, virtual models also offer an effective way to adapt teaching to the needs of students.

Methodology

Based on an analysis of the theoretical and conceptual foundations that link anatomical models as didactic mediation for the teaching of natural sciences, the research focuses on a methodological design of review of documentary works to reveal the focus of several authors in the arrangement of their data. This process involves observation and content analysis to systematize and argue the findings.

In this research, a qualitative paradigm was adopted, which allows reflection and critical analysis of the data obtained. This approach is based on the idea that reality is complex and multifaceted, and that it cannot be understood through the mere observation or measurement of variables. Instead, the qualitative paradigm focuses on the interpretation and understanding of data, through a reflective and critical process of its categories of study. As evidenced by Creswell, J. W., & Cázares, D. I. C. (2005), in his book *The Use of Theory in Educational Research*, (4), 1. In which they raise the importance of the reflective and critical process in the analysis and interpretation of data. This process involves a deep and detailed exploration of the data, through the identification and analysis of emerging patterns, themes and relationships. This process allows for a deeper understanding of participants' experiences and perspectives, which in turn helps researchers develop more detailed and contextual theories and explanations of the phenomenon studied.

It is important to highlight that teachers consider the different problems and interests of students, this is how innovation takes a vital role in the teaching process of natural sciences, these tools are important due to their ability to allow researchers and students to explore the different processes that occur from the living environment and the physical environment. In a more detailed and precise way. In addition, these tools can facilitate understanding by allowing students to visualize the structure and function of biological systems in a three-dimensional way that can be difficult to comprehend. It is decisive to highlight that the ongoing research is a contribution from the documentary exercise, contrasting theories and research that incorporate processes of exploration, classification and evaluation of events that are evidenced from the explanation of phenomena and that articulate technological development from the incorporation of new digital tools that significantly impact the classroom practices of teachers.

Results and discussion

To understand the natural sciences as a practice that links the social, is to understand that its focus of attention and execution assumes essential elements in academic contexts, assuming its action from the understanding, assimilation and transmission of knowledge, where practice permeates and in this evidences the innovation resulting from the co-creation of collectivities.

Although the sciences enable the acquisition of key competencies for the optimal development of students' processes, it is essential to provide the tools and strategies that enable them to do so, that is, trainers must be the foundations in the management of knowledge from the teaching and learning processes, articulating the different contexts from the chemical, biological and physical that give rise to the environment. The research center la casa del maestro is the propitious scenario for the development of each of the axes that articulate knowledge, know-how and of course being.

As a result, the importance of intervening in the teaching and learning methods of the natural sciences to develop processes from inquiry in different spaces of scientific co-creation with the support of emerging mediations is highlighted. As mentioned by municio, j. I. P., pozo, j. I., & creso, m. A. G. (2009). In his book; learning and teaching science: from everyday knowledge to scientific knowledge the author highlights the importance of science teaching as a dynamic process that encourages the active participation of students in the construction of scientific knowledge through inquiry and work in spaces of scientific co-creation, supported by emerging technological tools.

This involves changing the way in which teaching is done, moving from a model focused on the transmission of information to one focused on participatory learning and the construction of knowledge through experimentation and problem solving. In this way, it seeks to promote in the student their ability to apply scientific knowledge in daily life situations.

In this context, various research has been carried out on the implementation of anatomical models and technological development in the teaching of natural sciences, with the aim of promoting critical thinking and imagination of students, as well as delving into content more in line with their interests and tastes.

In this sense, several authors agree on the outstanding results of this research, which aim at the development of competencies, experimenting and exploring scientific concepts in a more active and participatory way, which contributes to better learning and understanding of them.

The matrix presented presents the findings found in relation to the research topic

Year	Author	Title	Analysis category	Argumentative position
2022	Ordoñez játiva, a. E., & villagómez antamba, a. L.	Anatomical models for the teaching of the musculoskeletal system in the area of natural sciences for third-grade egb students of the u. E 17 de julio de ibarra, february-july 2021 (bachelor's thesis).	Anatomical models – teaching natural sciences	The objective of the research was to propose the use of teaching-learning strategies of the musculoskeletal system in the area of natural sciences using anatomical models for students of the third year of basic general education of the educational unit "17 de julio" of the parish of el sagrario in the city of ibarra. The present work is a mixed research of descriptive scope; the survey with an 8-question questionnaire was used as a technique, which was applied to fifty children and an interview with a 5-question questionnaire, which was applied to two teachers belonging to the third year of basic general education. In the results, it was found that most of the students do not know and have shortcomings about the subject of learning the musculoskeletal system and, on the other hand, in the interview applied to the teachers, it is evident that there is little use of anatomical models, as a strategy for teaching the topic mentioned above. It is concluded that the use of the guide with both physical and digital strategies of anatomical models within the musculoskeletal system is important since it will promote significant change through experiential learning.

2022	Moreno cubela, f. J., ramos garcía, a., briones castillo, a. I., ruiz medina, j. M., & moreno labrada, f. A.	Three-dimensional models of the human brain: didactic materials on human anatomy.	Anatomy – three-dimensional models	Three-dimensional models of the human brain are proposed: didactic materials on human anatomy and an approach to these structures, its objective is framed in the elaboration of didactic means on the anatomy of the human brain, useful for the improvement of the teaching-learning process in the career of medicine. From an extensive review of bibliographic materials to obtain the theoretical framework, they delve into the need to change the teaching practices of teachers, thus allowing a closer interaction with the object of study. In its conclusions, it is possible to show that these models allow the development of professional skills and values from their elaboration to their presentation. They can be generalized and reproducible by the student and teacher community in other contexts where they are useful.
2021	Alarcón, b. M. G., cubela, f. J. M., isern, j. F. V., núñez, r. G., zamora, d. A., & reyes, e. R.	Three-dimensional models of the organ of vision, a contribution to medical and ophthalmological education.	Anatomy – three-dimensional models	From the research three-dimensional models of the organ of vision, a contribution to medical and ophthalmological education. The main purpose of this study is to develop three-dimensional models on the organ of vision and the fundus, which as a result mention that the elaboration of models as didactic-methodological means for teachers, aimed at medical students and assistants and residents of ophthalmology, which provide tools to acquire practical skills and guarantee the appropriation and application of the essential nuclei of the useful contents on the organ of the eye. Vision.
2021	Calle fernández, g. M.	Design of didactic material for learning human anatomy first year of the medical degree	Anatomy – didactic model	Learning medicine entails a lot of responsibility, especially in the subject of human anatomy; however, due to the breadth of the subject, first-year medical students require didactic resources for their cognitive and sensory development. For this reason, it is proposed to take didactics, user-centered design and the maker movement as a reference to generate a solution through the design of didactic material, resulting in three anatomical models that reinforce the learning of human anatomy focused on the study of the brain.
2021	Mosquera-serpa, e. A.	Strengthening the teaching-learning process of natural sciences in grade 6-a students through the implementation of augmented reality.	Augmented reality – teaching natural sciences	The research aims to explain whether the application of augmented reality as an emerging technology favors innovation and improves the teaching-learning processes of natural sciences with the subject increasing the human digestive system. For the study, a total of 42 students were taken into account, who were characterized, through a didactic sequence where augmented reality was used as a strategy or learning tool in the

				<p>educational environment, to seek to strengthen significant learning, academic performance and positively increase levels of concentration and participation in class. Optimizing or adding key information, which makes it easier for them to understand the activities proposed in the classroom. For the execution of this work, a mixed research methodology is used, based on the constructivist pedagogical model of the educational institution, which is supported by significant learning. On this occasion, amentaty creator was used, a program supported by an application called scope, which was downloaded to a cell phone, from there the students manipulated and observed images magnified through markers each part of the human digestive system. In which positive results in learning were evidenced, as well as significant achievements in the motivation, interaction and attention of the students</p>
2021	Mendoza fuentes, c. A.	Enhancement of learning in the natural sciences using augmented reality as a didactic strategy. Zona próxima, (35), 67-85.	Augmented reality - natural science learnings	Augmented reality is a technological tool capable of permeating different social fields and occupies an important place in education, developing applications with fundamental information on topics of study in the classroom and promoting an interest in learning in students. This provokes interest in students, which makes the proposal to implement an augmented reality resource to be applied in the classroom pertinent.
2021	Anaya dager, b. D. C., espinosa maderas, y., & sanes anaya, l. M.	To strengthen the competence of the comprehensive use of scientific knowledge in the teaching of natural sciences, through augmented reality technology in sixth grade students of the nechí educational institution	Comprehensive use of scientific knowledge - natural science teaching - augmented reality	The research developed arises from the problem related to the minimum level of competence comprehensive use of scientific knowledge in the area of natural sciences of sixth grade students of the nechí educational institution. The research had a mixed approach, to carry out the proposal the use of augmented reality was taken into account as a strategy to improve the teaching process. For the selection of the sample, the non-probabilistic sampling technique was used, intentional type made up of 40 students of the sixth grade. A pre-test was applied to diagnose the students' previous knowledge, then a didactic sequence was designed using the applications amentaty and quiver vision, to validate the implementation of the didactic sequence a post-test was carried out to measure the progress of the students. After the pedagogical intervention, it is concluded that the use of augmented reality strengthens the teaching of natural sciences and improves the classroom environment, allowing meaningful learning.

2020	Ayón-parrales, e. B., & del carmen víctores-pérez, m.	Simulation: support strategy in the teaching of natural sciences in elementary and baccalaureate	Simulators – technology – teaching natural sciences	<p>The objective of this study was to analyze simulation as a support strategy in the teaching of natural sciences at the level of basic education and high school in portoviejo. Ecuador. In order to fulfill this purpose, a bibliographic review of published works on this technique was carried out. From the methodological point of view, this research assumed a methodology with a qualitative approach, within the framework of which content analysis is used, through a documentary-bibliographic review. To this end, literary materials were selected according to criteria such as relevance, relevance, contributions and year of publication between 2015 and 2020. However, studies from previous years were included, given the significant contributions to this study.</p> <p>The results obtained indicated that students prefer virtual tools to conventional classes. The use of equipment such as pasco scientific for science teaching provides the possibility of working in a protected and safe teaching and research environment, in addition to offering practices at a lower cost, and extending the laboratory concept to the classroom and to the home of each student through the use of the computer. It was concluded that: the use of teaching materials and the use of ict offers better performance than only the teacher's classic theoretical explanation and therefore, virtual simulators contribute positively to the learning process of students.</p>
2020	Torres, f. A., martínez, m. U., peso, j. I., díaz, c. M., & vásquez, s. M.	Models as a didactic strategy for health students.	Anatomical models – physiological processes	<p>This production aims to propose the elaboration of models, or anatomical models representative of physiological processes corresponding to the normal functioning of the human being, as a dynamic methodology in the learning of physiology. In their conclusions, it can be seen that considering the use of various representations or didactic models to make explanations in the classroom promotes a greater understanding of the topics to be dealt with in physiology. In addition, this practice promotes collaborative work, stimulates action in pursuit of a goal and involves team members in all areas of the model construction project and encourages creativity. In this sense, giere and moffatt allude to the fact that students, by developing representative models, can construct new ad hoc representations to solve specific problems, using both their representational skills and creativity.</p>

2020	Viviescas, a. X. G., & sacristán, y. A. M.	Experimentation in the natural sciences and its importance in the training of elementary school students.	Experimentation in the teaching of natural sciences	<p>This article reflects on the importance of experimentation in the teaching of natural sciences, through the analysis of the approaches of different authors. This reflection externalizes the need to implement experimental practices in the classroom, especially at the basic education level, where the skills of curiosity and observation are configured as a key element in the articulation of the biological and the social. Underlying this process is the detailed observation of the phenomenon, the construction of questions, the formulation of a hypothesis, its verification and the "artiphilization" of the object of study, accompanied by the teacher's purposes in teaching. Therefore, experimentation is configured as a mechanism by which the student becomes the protagonist of his learning and a conscious subject of the relationships he establishes with his environment.</p>
2020	Osorio-toro, s.	Experimental practice of dissection and 3d modeling of the middle and inner ear for the significant construction of knowledge in the area of human anatomy.	3d modeling - human anatomy	<p>Unveiling the importance and understanding of human anatomy and especially of some very small organs such as the middle and inner ear, is challenging due to its complex three-dimensional structure, from the research proposes to build knowledge in the understanding of the anatomy of the human middle and inner ear, from the experiment of dissection and 3d modeling. With dicom images from a computed tomography of the human ear converted to a 3d model (mimics) and cadaveric dissections of the temporal bone, for which the bony and soft structures of the outer, middle and inner ear were designed by implementing organic modeling software.</p> <p>Experimentation, in this case, the dissection and modeling of anatomical pieces was fundamental in the teaching and learning of this area of science, allowing knowledge to be built from the search for information, observation, analysis and reflection. The students expressed fascination and deep learning in the practice carried out. The construction of explanatory models around qualitative experimentation allows for an in-depth understanding of the different phenomena.</p>

2019	Carrascal andrés, m.	Methods used for teaching the human body in primary schools.	Anatomical models – digital technologies	This research work has aimed to verify whether anatomical models and/or the use of digital technologies affect the academic learning of primary school students in relation to the human body. To this end, the different methods used by teachers today for teaching the human body and their effect on the learning of this subject have been investigated, analyzing current textbooks and conducting a survey of primary school teachers. We have observed that the use of plastic models and digital technologies for teaching the human body in primary schools does not significantly improve students' grades, although a trend of improvement can be observed.
2019	Ruiz cerrillo, s. (2019).	Teaching anatomy and physiology through augmented and virtual realities	Augmented reality – anatomy – natural science teaching	Innovation in the teaching of anatomy and physiology can be favoured with the implementation of new information and communication technologies (icts), such as augmented reality (ar) and virtual reality (vr). The objective of this article is to analyze the impact of teaching with ar and vr in high school students in the teaching-learning process of the subjects of anatomy and physiology. The text is the result of a research that used a mixed approach with the use of the action research method, where a questionnaire adapted from the technological acceptance model was used as the main instrument (davis, 1989). In conclusion, students improve their teaching-learning process with ar and vr by increasing motivation towards the development of cognitive competencies, such as the identification of human planimetry.
2019	Murcia, j. P. M., & ruiz-funes, m. J. M.	Categorization of didactic materials for teaching living beings in the old cabinets and laboratories.	Teaching materials – taxonomy	This contribution deals with the categorization of the scientific-didactic materials that were used for the teaching of life in the classrooms, cabinets and laboratories of some of the historic educational centers of Spain. Under a multidisciplinary approach between biology and the history of education, the genesis, manufacturing characteristics, functionality and didactic uses of these materials are studied. From the idea of the "fossil object or footprint", we establish a starting point to propose a taxonomy of the material that takes into account its use in the classroom, differentiating between representative material, collections of living beings, optical and experimental instruments.
2019	López, a. M. M., plaza, a. D., soldado, n. A., conde, l. D., benitez, a. J. L.,	Development of anatomical models using plastination techniques as an alternative to the use of animals in teaching and as an essential	Anatomical models	The objective is to develop models using plastination techniques of different animals (mouse, rat, guinea pig and rabbit) as a teaching resource for the biosciences disciplines that are being taught in the

	galisteo, a. M., ... & salvago, r. M. (2019).	resource in the teaching-learning process.		official degrees of the university of cordoba that involve the use of animals, always seeking their maximum dissemination among the teaching staff. The research as a result has served to show students as well as teachers, the possibility of applying the principle of the 3 rs in the teaching of very diverse university degrees. By means of the plastination technique, models of laboratory animals faithful to reality can be created, which can be used as an alternative to the use of animals in teaching, thus reducing the use of these by inexperienced personnel, guaranteeing the acquisition of greater skills and, therefore, preserving animal welfare at the time that an in vivo procedure has to be performed.
2019	Cepeda sainea, j. F., & silva ortiz, s. R.	Learning anatomy through an interactive three-dimensional system.	Anatomy – augmented reality	Numerous studies establish that technological means correspond to a necessary tool for the teaching of any discipline, as in the case of anatomy where the models developed by technology in three dimensions allow a vision of the spatial relationships of the human body from medically accurate models of anatomy. However, what may be significant for the teacher in the learning of the students, for them may or may not be to their liking and will end up influencing this process in a positive or negative way. Thus, in this research, the process of learning anatomy is described from the experience of the students with the use of educational software with cadavers and 3d holographic hardware.

Conclusions.

Natural sciences are fundamental in the education of students, as they allow the development of cognitive skills and competencies to understand and analyze the world around us. Despite their importance, the lack of knowledge of appropriate didactic and technological strategies for teaching these disciplines can hinder learning. Therefore, it is necessary to adapt education to an increasingly complex and changing world, using the tools and technologies available to help students understand and navigate this environment.

In this sense, a documentary review research has been carried out that links science teaching with anatomical models and augmented reality. This research suggests that the use of technology in the classroom can significantly improve students' understanding of complex anatomical and biological concepts. By using anatomical models and augmented reality, students can interact with the objects of study in a more practical and visual way, allowing them to better understand the structure and function of biological systems. In addition, technology can also provide a more immersive and engaging learning experience, which can motivate students to engage more with the material and learn more effectively. In conclusion, the use of technology in the teaching of natural sciences can be a valuable tool to improve student learning and prepare them to face the challenges of the modern world.

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