

# Digital Technological Innovations in the Teaching of Human Anatomy in Health Courses: an Integrative Review

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## ABSTRACT

**Introduction:** teaching human anatomy has traditionally relied on techniques such as the dissection of human cadavers and the use of textbooks, but a significant decline in body donations in recent years, coupled with the Covid-19 pandemic, has led to new technologies being created and those that already existed became more widely used. Despite the growing interest in the use of active methodologies and digital technologies in anatomy teaching, studies are scarce regarding the evaluation and effectiveness of these tools. Therefore, the objective of this study is to identify the main digital educational technologies that have been used in the teaching of Human Anatomy in the last three years with positive results.

**Review:** when performing an integrative review using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, we searched for studies in English and Portuguese in the Google Scholar, Scielo, Science Direct and PubMed databases. Initially, 605 articles were identified, after removing 10 duplicate articles, 570 were excluded according to our exclusion criteria. Of the 25 articles included, 4 (16%) articles are related to the teaching of anatomy in nursing courses and 21 (84%) in the medical course.

**Conclusion:** Overall, the results indicate that most of the articles identified and related to digital technologies associated with active methodologies, obtained satisfactory results both in learning the contents and in the motivational issue for teaching Anatomy.

**Keywords:** Teaching; Educational paradigms; Digital Resources.

## Introduction

Anatomy is the part of biology that studies the morphology or structure of living things. In its broadest concept, it is the science that studies, macro and microscopically, the constitution and development of the human body. Anatomy originates from the Greek word meaning to cut into parts, to cut apart without destroying the constituent elements. It is equivalent in Portuguese to dissect<sup>1</sup>.

Human Anatomy is a fundamental basic discipline in the curriculum of any undergraduate course in health, whether it is approached in a systematic or segmented way, being one of the pillars common to the various health courses, helping, a posteriori, in the understanding of subsequent disciplines<sup>2</sup>.

It has its own nomenclature called Anatomical Terminology with about 5,000 words that allow naming, identifying, and describing the various macroscopic structures of the human body<sup>3</sup>. Mastering the knowledge of Anatomy is equivalent to learning a “new language”, in addition to introducing the student to the knowledge of medical terminology.

How to teach human anatomy to new learners? The teaching and learning processes are permanent in the construction and improvement, whether in early childhood education or adult education. The student

needs to acquire knowledge, psychomotor skills and attitudes that allow him to develop the necessary skills for a substantive professional training. Thus, several disciplines of undergraduate courses in the health area, given a greater challenge to the already complex teaching-learning duet, needed to adapt to the reality of the student, in order for him to adopt an active role in the construction of his knowledge.

Classically, the teaching of anatomy focused on theoretical, expository-dialogued classes and practical classes, on the study of the cadaver through dissection, often in a dissociated way from each other<sup>4,5</sup>. This traditional methodological approach, where the teacher is the protagonist of teaching, makes the student act passively during classes, which makes it difficult for him to understand the concepts and their applicability in real situations.

Another setback that impedes learning is the donation of bodies for teaching anatomy, which has been decreasing significantly in recent years, in addition to expressive concerns regarding the difficulty of maintaining these<sup>6</sup>. Because of this logistical problem, students may struggle to gain a holistic understanding of the continuity of structures from their origins to their functions, which may challenge their understanding of more detailed anatomical

relationships.

With the growing technological advance in society, it was necessary to rethink the resources used for teaching anatomy and to have new technologies, especially digital ones, adapting them to this new context. Such technologies have been updated and the contents covered are more available to students in different means and technological supports<sup>7</sup>.

In recent years, both the insertion of Active Methodologies and new digital technologies in the teaching of Anatomy has been beneficial for the improvement of educational processes, since such strategies work in consonance with theory and practice, providing students with a profile that grants them autonomy, teamwork, critical thinking, creativity and logical reasoning in the face of different situations of educational daily life, allowing them to build their own knowledge from the teacher's mediation<sup>5</sup>.

Another positive factor highlights that these approaches make anatomy teaching more interesting, interactive and engaging, and help them with deep learning, effective retention and application of knowledge in the clinical context<sup>8</sup>.

In this review article, however, the objective is to identify the main digital educational technologies that have been used in the teaching of Human Anatomy in the last three years with positive results, since there are already consistent works that address the topic of Active Methodologies.

## Methods

In this study, which is an integrative literature review, digital educational technologies were defined as a research topic from the perspective of Human

Anatomy teaching. The integrative review is a method that synthesizes the knowledge already published on certain topics and that uses the results of significant studies to apply them in practice<sup>9</sup> and has five steps: the formulation of a guiding question, the literature research, critical literature review, qualitative data analysis and presentation of results<sup>10</sup>.

For the first stage, the following guiding questions were formulated based on the PICo strategy (Population/Patient/Problem), the phenomenon of interest (Interest) and the context (Context): Which digital educational technologies are currently used in Anatomy teaching in medical and nursing courses? What is the impact of digital technologies on pedagogical practices carried out in Anatomy teaching in medicine and nursing courses? This strategy tends to seek more qualitative studies focusing on human experiences and social phenomena<sup>11</sup>.

In the second stage, for the literature review, the research was carried out in April and May 2022, in the following databases: Google Scholar, Scielo, Science Direct and PubMed with the following combination of keywords: Anatomy, Technologies Digital Educational, Anatomy teaching, and Digital Education Technologies.

As inclusion criteria, full articles within the proposed theme from 2019 to 2021, published in well-evaluated Scientific Journals, with free access, written in English and Portuguese and in the areas of Medicine and Nursing were considered. As exclusion criteria, the following were not considered: theses, dissertations and course conclusion works, articles outside the proposed theme, review articles and without free access. Figure 1, called Prisma Flow, presents a systematization of the results obtained with

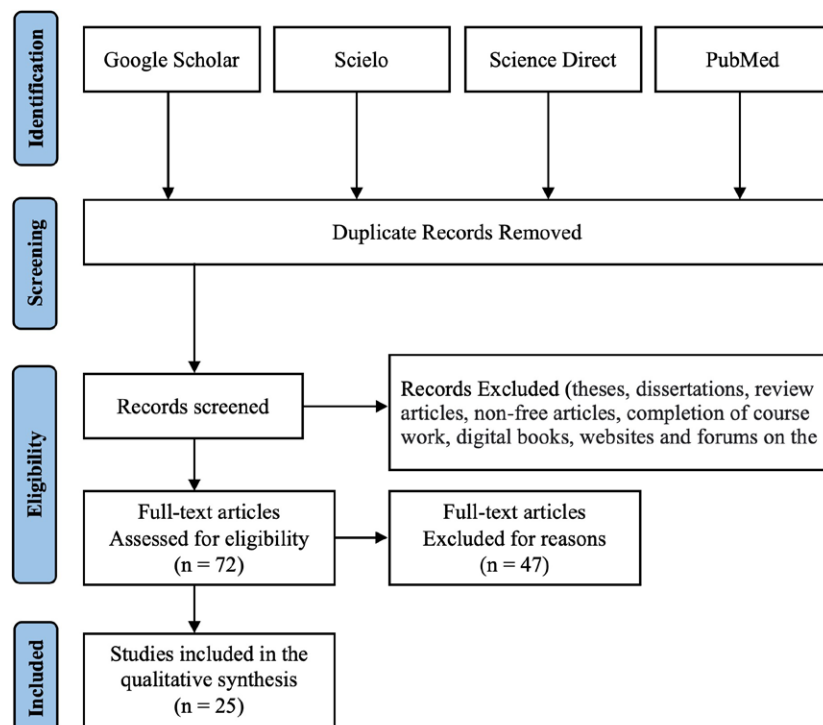


Figure 1. Flowchart of the studies selected in the integrative review. Source: own elaboration.

the search in the databases.

After searching the databases, the selected articles were analyzed in detail and their information was examined according to the author(s), the objective, the main results, the conclusions, and the scientific journals that were published, in order to achieve the objective proposed by the guiding question of the review. Finally, the discussion of the works found was presented.

## Results

After the search stage, 25 articles were selected according to the established inclusion criteria, after reading the abstracts and those that best fitted the answer to the guiding questions of the review. For the qualitative synthesis, 13 articles from Google Scholar, 8 articles from Science Direct and 4 from PubMed were used. Of these, 4 (16%) articles are related to anatomy teaching in Nursing courses and 21 (84%) in Medicine courses.

The articles analyzed highlighted innovative digital technologies, both in terms of hardware and software, and most of them highlighted important results in the learning of students in medical and nursing courses, highlighting the effectiveness of using these technologies in relation to theoretical-practical aspects (learning concepts and practices with simulation of real situations)<sup>12-14</sup> and the motivation of students explained in their perceptions and in those of Anatomy teachers<sup>15-18</sup>.

## Discussion

In recent years, science and technology have seen rapid changes and developments that are reflected in education processes. Given the unique characteristics inherent to the discipline of Human Anatomy, such as, among others, promoting an introduction to medical terminology through the expressive number of new terms that the student must seek to learn and associate with the structures and their respective functions, which, in itself, already represents a great challenge for those starting a health undergraduate course. In this way, Anatomy teachers are challenged to develop and test new teaching and learning methodologies and resources that meet the demands of this current context.

Technological and media development, the reduction in the workload of the Human Anatomy subjects in the new curricula of health courses and, in Brazil, the reduction in the donation of human corpses for teaching purposes, were factors that further accelerated this challenge to seek to develop new pedagogical approaches and technological resources for teaching Anatomy. In addition, as the student “comes across” it at the beginning of his undergraduate course, Human Anatomy ends up taking on another mission: to provoke/bring/generate/increase/motivate learning

in the pursuit of professional excellence.

The emergence of the pandemic, if on the one hand, moved away from face-to-face interaction, on the other hand, it boosted the integration of Anatomy teaching with the paradigms of andragogy, either using active methodologies or the emergence of the need to increase the handling of digital technologies to improve the quality of the art of teaching Anatomy.

It is not by chance that anatomy has been a fertile field for several pedagogical essays that have been introduced and tested in parallel with technological and digital advances in recent decades, among which we highlight the development of hardware and software to facilitate the ability to reason and deduce in 3D. The unwanted and disturbing human impact caused by the Covid-19 pandemic provoked, in contrast, the emergence of a “teaching revolution” that was already present, although, in general, in a punctual and experimental way<sup>16</sup>.

As observed in this review work, there are several teaching approaches supported by digital technologies (Hardware and software), of which we highlight some for their innovation, impact, scope and/or feasibility for the teaching-learning of Anatomy: 1) digital images stereoscopic 3D (which are composed of two separate digital images, each with a different eye)<sup>19</sup>; 2) virtual reality tools<sup>20</sup>; 3) Instagram (social network) for posting teaching material<sup>17</sup>; 4) expansion and updating of the Virtual Learning Environment (AVA)/Computer-assisted Learning (CAL) of Universities<sup>21</sup>; 5) Use of the virtual dissection table in classes, integrating with cadaver dissection<sup>18,22</sup>; 6) Use of the WebQuest tool (platform) as a complementary learning element<sup>14</sup>; 7) online memorization games with cards that associate words and concepts with figures or topics<sup>23</sup>; 8) application of quizzes (photos and videos linked to questions and answers) through social networks and smartphones on the Google Forms platform<sup>24</sup>; 12) 3D printers<sup>18</sup>; 13) mixed reality (3D images with holograms) and the Human Muscle Arm Avatar<sup>12</sup>; 14) use of Ipad<sup>15</sup>.

Blended teaching started to be approached in many countries, generating the emergence and development of several anatomy teaching tools, such as recording classes, use of videos, podcasts, dynamic 3D atlases, tutorial group sessions, collective construction of maps, concepts, among others<sup>25</sup>.

Some Universities, although they already had a VLE-Virtual Learning Environment (E-learning), sought to expand, and improve their content available to students, as was the case of UFMG and the University of Oxford<sup>21</sup>. In parallel, digital tools allowed the formation of anatomy study groups to establish knowledge through quizzes, a repository of selected texts, podcasts, use of files from the Web itself, as mentioned in several analyzed articles<sup>24</sup>.

In healthcare courses, the study of anatomy is usually focused on the first year of graduation. Upon reaching the clinical phase of the course, details

of anatomical structures are often forgotten, with difficulties in correlating with the signs and symptoms of diseases and syndromes. Technological resources such as the Surface Hub allow a direct connection through videoconference between clinical and basic science professors in real time, for discussion in clinical sessions<sup>26</sup>. Thus, these sessions extend anatomy

teaching vertically into clinical training, which is highly desirable in an integrated medical curriculum<sup>27</sup>.

In health teaching and learning, many technological innovations are being introduced, such as 3D printing, which has gained popularity in medicine in the last decade<sup>28</sup>. In surgical planning, computed tomography and nuclear magnetic resonance were conventionally

**Table 1.** Main references of articles included in the integrative review

Author and year	Objective	Main results	Conclusion	Scientific Journal	Databases
Alkhowailed, M. S <i>et al.</i> , 2020 <sup>34</sup>	Disseminate the digital resources used in teaching medical students at the Faculty of Medicine of Qassim University.	Digital learning tools facilitated the performance of students and their peers by sharing knowledge. The role of computer technologies was evident in promoting students' research skills and technical skills.	The present work elaborated on the procedures and privileges of the transformation of digital learning, articulating the PBL sessions, recommended the adoption of future theoretical courses, as well as the development of digital technologies.	Informatics in Medicine	PubMed
Allsop, S. <i>et al.</i> , 2020 <sup>26</sup>	Use of videoconferencing technology for teaching anatomy in the clinical stage.	Shared experience and shown the advantages of using videoconferencing to bridge the anatomical and clinical components, while acknowledging its limitations.	It demonstrated the possibility for others to experiment with new and innovative methods of exploring anatomy teaching in the distributed models of medical education seen during the clinical years of medical training.	Translational Research in Anatomy	Science Direct
Bannovac, I. <i>et al.</i> , 2021 <sup>35</sup>	Compare the effectiveness of the different online and face-to-face components of anatomy classes from the perception of medical students	Approximately 90% of students considered anatomical dissection and practical work in general to be the most important aspect of teaching that could not be replaced by online learning. Few students found the face-to-face lectures useful, most considered the recorded video lectures to be extremely useful for the study.	Anatomical dissection and interaction during face-to-face classes remain the most important aspects of anatomy teaching. However, online teaching increases theoretical learning efficiency by allowing alternative learning strategies, replacing face-to-face classes, thus freeing up more time for practical work.	Croatian medical journal	PubMed
Baptiste, Y. M., 2021 <sup>36</sup>	Explore the effects of the Covid-19 pandemic) on the evolution of physical and digital cadavers within the unique ecosystem of the anatomy lab.	Adaptation of physical and digital cadavers during the pandemic was analyzed and the resilience of digital cadaver technology was recognized.	The evolving role of the digital cadaver was considered in terms of increasing accessibility and inclusion within the anatomy lab ecosystem of the future.	Anatomical Sciences Education	PubMed
Bianchi, S. <i>et al.</i> , 2020 <sup>37</sup>	Test the use of the virtual dissection table in teaching anatomy to nursing students by assessing the anxiety level before the exam and by the exam result.	Feedback from the evaluated population was positive.	The use of the virtual dissection table integrated with the study of anatomy improved the learning performance, but also the self-confidence of nursing students.	Applied Sciences	Google acadêmico
Cakmak, Y.O. <i>et al.</i> , 2020 <sup>38</sup>	To evaluate the use of the tool "The human muscular arm avatar (HMAA)" for the learning of human anatomy by medical students.	The main findings of the usability study suggest that 98% (N ¼ 100) of students is an extremely useful tool; 83% reported that the tool allowed them to engage with learning materials, peers, and content effectively. Additionally, 10% of students mentioned that HMAA promoted an embedded learning experience.	It is believed that the HMAA allowed the visualization and conceptualization of abstract ideas. The results indicate the significant potential of tools based on "body ownership" compared to current learning techniques.	IEEE Transactions on learning technologies Yusuf Ozgur Cakmak	Google acadêmico



<p>Chekrouni, N. <i>et al.</i>, 2019<sup>33</sup></p>	<p>Examine whether using the 3D atlas adds educational value and enhances students' learning experience.</p>	<p>Results showed that Atlas 3D significantly improves students' understanding of human embryology, reflected in significantly higher test scores for new students.</p>	<p>The 3D Atlas of Human Embryology has proven to be a valuable resource in addition to existing resources for teaching the intricate developmental processes of human embryology, especially in a blended learning curriculum.</p>	<p>Annals of Anatomy.</p>	<p>Science Direct</p>
<p>Chen, C-J <i>et al.</i>, 2021<sup>30</sup></p>	<p>Demonstrate the benefits of using 3D holograms in a higher education environment.</p>	<p>A total of 79 participants (40 in the intervention group and 39 in the control group) were included in the final statistical analysis. The response rate was 88%. Statistically significant differences in knowledge and practical learning in the health assessment and practical course were observed between the intervention group and the control group (<math>p &lt; 0.05</math>). The <math>\eta^2</math> effect level was 0.134.</p>	<p>After attending lectures, students who also attended 3D hologram-based laboratory courses scored significantly higher on knowledge and hands-on learning. This approach can be used as a complementary learning tool in higher education.</p>	<p>Nurse Education Today</p>	<p>Science Direct</p>
<p>Chytas, D. <i>et al.</i>, 2021<sup>19</sup></p>	<p>Investigate whether 3D stereoscopic images improve anatomy teaching compared to 2D.</p>	<p>The study in non-stereoscopic and stereoscopic 3D models had a significant result in relation to 2D.</p>	<p>There should be a comparative study between several 3D models, especially with cadaver dissection.</p>	<p>Surgical and radiologic Anatomy</p>	<p>Google acadêmico</p>
<p>Darras, K. E <i>et al.</i> 2019<sup>22</sup></p>	<p>To investigate the feasibility of integrating the virtual dissection table into a cadaver-based anatomy course in the first year of medicine.</p>	<p>Most students (78%) reported that virtual dissection improved their understanding of cadaver anatomy and the clinical applications of anatomy. 73% thought that the use of the virtual dissection table was effective in the lab time.</p>	<p>The students found that the integration between cadaver dissection and the virtual dissection table improved learning in the anatomy lab.</p>	<p>BCM Medical Education</p>	<p>Google acadêmico</p>
<p>Dourado, V. M. <i>et al.</i>, 2020<sup>24</sup></p>	<p>Understand the perception of medical students about the introduction of quizzes as an innovative methodology for teaching anatomy, pathology, and radiology.</p>	<p>He noticed the progressive adhesion of the students throughout the 3 quizzes with more positive than negative points in relation to help in learning.</p>	<p>It is a good option for an interactive methodology, as it is based on digital media linked to questions and answers, being an additional factor of study.</p>	<p>Brazilian Journal of Development</p>	<p>Google acadêmico</p>
<p>Kazoka, D. <i>et al.</i> 2021<sup>18</sup></p>	<p>To verify the perception of medical students regarding the learning of anatomy through the combination of the classic method with the use of the virtual dissection table and 3D printed models.</p>	<p>In the combined study, students used the virtual dissection table more than the other tools; the largest percentage of them reported using the combined study to deepen their understanding of human anatomy and to help link the basic and clinical sciences.</p>	<p>The use of digital images and printed 3D models are becoming tools not only to improve the study of anatomy, but also in clinical studies.</p>	<p>Education Sciences</p>	<p>Google acadêmico</p>
<p>Korniienko, I. A. <i>et al.</i> 2020<sup>20</sup></p>	<p>Identify the educational advantages and disadvantages of virtual reality in anatomy teaching.</p>	<p>Virtual reality exhibited an enhanced learning experience when compared to traditional learning.</p>	<p>The combination of visualization and interactivity makes virtual reality learning advantageous for effective education.</p>	<p>Informations Technologies and Learning Tools</p>	<p>Google acadêmico</p>

Leung, B. C. <i>et al.</i> 2020 <sup>39</sup>	Explore which resources are most useful for first-year medical students to learn anatomy.	Anatomy websites were the most used (30%), followed by tutorials (20%) and readings (19%). The university's computer-assisted learning platform was the least used. Changes in the urogenital section with the insertion of 3D images etc. increased their use from 12 to 27%. The result shows the importance of improving digital teaching platforms.	Educators must be aware of the spectrum of learning resources used by students to ensure that our own e-Learning platforms are optimized to meet the diverse needs of students.	Journal of medical education and curricular development	Google acadêmico
Lopez-Lopez, V. <i>et al.</i> , 2021 <sup>29</sup>	Develop three-dimensional models of hepatobiliary anatomy.	Thirty-five patients from eight centers were included with a considerable degree of similarity in vascular calibers and distances between the tumor and the vessel. A concordance between the 3DP and the surgical specimen was demonstrated with the distance from the resection margin.	3DP liver models correlate well with CT/MRI and surgical pathology and are useful for education, understanding, and surgical planning, but do not necessarily affect surgical outcome.	International Hepato-Pancreato-Biliary Association	Science Direct
Meneses, J. R. F. <i>et al.</i> 2021 <sup>17</sup>	To report the experience of creating an Instagram page as a facilitating tool for the adhesion of medical anatomy students amid the covid-19 pandemic.	The experience of managing an Instagram page brought the possibility of developing skills such as responsibility and commitment, given the need for scientific basis and avoiding wrong learning.	The search for strategies that expand students' interaction with human anatomy subjects was well accepted by individuals.	Research, Society and Development	Google acadêmico
Narnaware, Y.R. <i>et al.</i> , 2021 <sup>31</sup>	To verify the use of the three-dimensional (3D) virtual human cadaver in the teaching of human anatomy to nursing students in a quasi-experimental project.	The class average of correct answers in the intermediate and final exams and the overall grade point average was significantly higher in students taught with the virtual cadaver than in students taught without the virtual cadaver.	For nursing programs without cadaveric dissection, the virtual cadaver can serve as an effective teaching tool to increase anatomy knowledge and can improve long-term student knowledge retention.	Teaching and Learning in Nursing.	Science Direct
Oliveira, F. H. L. <i>et al.</i> 2020 <sup>23</sup>	Use of online memorization games to optimize human anatomy studies.	Online games made about the anatomy of the locomotor system. Game overhead – 51 hits; on upper limbs – 17 accesses; on lower limbs – 8 accesses.	Online memorization games promote an optimization of anatomy teaching, since virtual access makes teaching-learning more flexible and democratic, in addition to helping the student to develop practice with technological tools and stimulate creativity.	Brazilian Journal of Development	Google acadêmico
Oliveira, V.C.B.D <i>et al.</i> 2019 <sup>14</sup>	To assess the impact of medical students' performance on the anatomy teaching-learning process using the WebQuest tool.	The WebQuest platform was a facilitating tool in the teaching-learning process of anatomy.	Need to improve this tool for its insertion in the context of higher education of anatomy.	Regit	Google acadêmico
Pather, N. <i>et al.</i> 2020 <sup>16</sup>	Identify what are the perceived disruptions and changes made to anatomy teaching in Australia and New Zealand during the early period of the Covid-19 pandemic, as reflected by anatomy educators.	The analysis revealed loss of integrated practical experiences by students and impacts on the workload of anatomists looking for new ways of approaching anatomy by remote teaching.	There is no doubt that the teaching of anatomy has entered a yet unknown future in the countries of Australia and New Zealand.	Anatomical Sciences Education	Google acadêmico

Oz, G.Ö.; & Ordu, Y., 2021 <sup>13</sup>	To review the effects of the use of Kahoot in the context of web-based educational assessment on the knowledge and skills of intramuscular injection of nursing students.	The findings showed that the experimental group had significantly higher mean scores on knowledge and skill performance scores for intramuscular injection.	Web-based education and the use of Kahoot in assessment showed positive effects on nursing students' knowledge and skills of intramuscular injection.	Nurse Education Today	Science Direct
Pyörälä, E. <i>et al</i> (2019) <sup>15</sup>	Explore the uses of mobile devices for best practices of virtual annotations of content by self-reported medical and dental students.	Note-taking was the most frequent and consistent, students reported using iPads during their years of study. While taking notes, they processed the new information in an accomplished and personalized way in digital teaching materials, making comments, underlining, marking images and drawings. The visual nature of their learning materials stimulated learning.	Efficient digital note-taking practices were critical for students to become mobile learners. Having all their notes and learning materials organized into their personal digital libraries allowed them to retrieve them anywhere, anytime, whether studying for exams or treating patients in clinical practice.	BMC Medical Education	PubMed
Wang, C. <i>et al.</i> 2020 <sup>12</sup>	Assess what second-year medical students learned in anatomy 30 days after using various learning tools for 20 minutes.	The group of students who used mixed reality performed worse than the other 2 groups on nominal questions but had better retention on nominal and spatial questions. The 3D and mixed reality groups had higher engagement.	The study suggests that 3D tools are effective in improving anatomy learning. But there are several limitations such as limited sample size and various threats to internal validity.	Scientific Reports	Google acadêmico
Zhang, N. <i>et al</i> , 2021 <sup>40</sup>	To describe the development of an anatomy assisted teaching system for teachers and students based on anatomy knowledge points using digital resources.	This scientific, complete, and holistic system has produced more than 6,000 3D digital anatomical models, 5,000 anatomy knowledge points, 50 anatomical operation videos and 150 lessons, with teaching content for different courses and levels, such as systematic, topographical, sectional, of movement and virtual anatomical operating table and facilitated the learning environment.	This new teaching system serves as an important component and a necessary resource in anatomy teaching and serves as an important supplement to traditional anatomy teaching.	Virtual Reality & Intelligent Hardware	Science Direct
Zorzal, E. R. <i>et al</i> , 2019 <sup>41</sup>	3D reconstruction from anatomical slices allows anatomists to create three-dimensional representations of real structures by tracing organs from sequences of cryosections.	There were contributions with new interaction techniques aimed at promoting spatial understanding and speeding up manual segmentation.	Results indicate that Anatomy Studio encourages tightly coupled collaborations and group discussions to gain deeper insights.	Computers & Graphics	Science Direct

Source: Own elaboration

used as standard techniques. Recently, 3D visualization has been introduced in the surgical approach including the area of hepatobiliary surgery, which has facilitated surgical planning, teaching of surgical technique and physician-patient communication<sup>29</sup>.

In the nursing course, students were able to use the 3D hologram technological resource in the learning laboratory when the intervention group of this study watched the 3D hologram teaching content 17.5 times between the beginning and the end of the course with a 360° view. They experienced more meaningful

learning and were pleased to learn and share this new experience<sup>30</sup>. In another study, nursing students, without cadaveric dissection in the regular course, used the 3D virtual human cadaver in practical classes, with a record of improvement in long-term content retention<sup>31</sup>.

Other tools that drew attention were those that cited or evaluated the use of the digital dissection table, 3D images (stereoscopic and non-stereoscopic) and 3D printed models, in consortium or not with conventional anatomy readings and practices<sup>18</sup>.

It is known that knowledge of embryonic development is important to understand the intricate topographical relationships of the organs of the human body and to understand congenital malformations. Studying in textbooks with two-dimensional and static figures has limitations because in embryology several processes occur at the same time. The use of the 3D digital Atlas of Human Embryology<sup>32</sup> had a significant educational value added to the (bio)medicine student curriculum, especially when associated with lectures and painted physical models, which facilitated visualization of embryological processes not completely assimilated in theoretical classes<sup>33</sup>.

It is concrete that technology, with its multiple possibilities, advances, and cheapness, has shown us that, in addition to facilitating, it presents itself as a creator of new teaching methods, as recorded in the articles that presented and evaluated the efficiency, respectively, mixed reality (use of 3D holograms shown in head-mounted viewer) and human muscular arm avatar. Holograms are visualized by an eyepiece device and have been compared with the use of 3D images and with the traditional study – read-only. The use of the Human Muscle Arm Avatar – hardware and software coupled to identify and visualize on the computer screen the muscles used in each movement of the hand or fingers – emerges as a promising tool and of future application in active methodologies<sup>12</sup>.

Although all the articles showed positive rather than negative results, several basically measured the students' level of satisfaction with learning, but few promoted quantitative assessment of learning through statistical analysis, which represented an important limitation in this review.

In parallel with the profusion of digital technologies in search of pedagogical excellence, it is important to consider costs and accessibility, for the benefit of education for all, including undergraduate courses in underserved regions.

During so many innovations, whether hardware or software, the development of new methods and

technologies for the teaching and learning of human anatomy is a true “volcano in full eruption” to release and consolidate new possibilities of paradigms, which was demonstrated by the quantity and variety of research carried out in this area.

## Conclusion

The notoriety of the evolution of educational paradigms in the teaching of Anatomy in courses in the health area regarding the use of digital technologies, especially after the pandemic context of Covid-19, was highlighted, as well as the large number and variety of these that were used in the practices during the researched temporal space. Finally, it was also highlighted that such digital technologies associated with active methodologies, obtained satisfactory results both in content learning and in the motivational issue.

Among the limitations of the review, it was observed the reduced number of publications that addressed the use of digital technologies in the teaching of Anatomy in nursing courses, and that most of the studies that evaluated the use of technologies in the teaching of anatomy presented results described from the action and perceptions of students and teachers in relation to the learning process, which made these inferences subjective.

The perspectives of this study indicate that there is a need for more research with a quantitative approach that presents more significant results at statistical levels regarding the use of digital technologies in the teaching of Anatomy.

The search for better pedagogical efficiency from these new technologies should not be neglected, as well as the goal of its applicability due to cost-effectiveness should not fail to be associated with studies in textbooks. It is also necessary and desired that the face-to-face coexistence of students continues to confer positive emotional bonds of belonging and of jointly facing the difficulties of learning and apprehending knowledge.

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