Analysis and Implementation of VR in the Biomedical Area Used by Preservice Secondary Science Teacher Involved in the Practicum Experience

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Abstract: Nowadays, Augmented and VR in teaching disciplines such as Human Anatomy has made it feasible to promote learning through a gamification process that allows the development of teaching-learning proposals that improve students' motivation significant learning and not merely memoirist. This new practice moves away from the traditional methods used in Human Anatomy subjects. This work shows the result of implementing a methodology based on Augmented and Virtual Reality (VR) in high school students within the subject of human anatomy. Specifically, this implementation was developed in students (n = 16), all of them belonging to a public education center. Moreover, they were involved in nursing care, primary nursing techniques. The results, derived from the analysis of the instrument used to assess their level of acceptance and their level of learning, showed a significant increase in both motivations for learning and the acquisition of knowledge in the area (significance * p <0.001, ANOVA). Our study concludes that the use of Augmented and VR improves the learning and motivation of students in daily practice.

Keywords: Virtual reality, Human anatomy, Secondary high school

Introduction

The current technological development, and the adaptation of the generations of young people who have grown up and developed between screens, video consoles, tablets, etc., have made it possible to involve this technology in the curricular plan (Torres Santomé, 2015). The technological impact allows transforming educational instruments into others much closer to the current reality (Aguilar, 2012). Education has the responsibility of articulating social changes adapting to technological progress (Minguélez-Juan, 2018 and Minguélez -Juan, Núñez, and Mañas-Viniegra, 2019). Furthermore, this fact has become decisive due to the confinement situation caused by the COVID-19 Pandemic.

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Presently, the interest of students both in child age, as adolescents or teenagers, is very receptive to the use and application of novel technologies that arise from education. These new technologies are a source of captivating experiences, which allow sharing in a natural, active, and participatory way their knowledge, skills, and practices. All this is with a network approach to online learning. That is why the Android and iOS settings offer free applications that can improve students' teaching and learning processes (Moreno-Martínez, Leiva Olivencia & Matas, 2016; Olivencia 2013). Furthermore, the diversity of media and multimedia elements that contain the internet (high quality 4K images, animations, etc.) joined with the flexibility of communication and information offered an increase in the motivation for the classes since they obtain a reinforcement immediate (Ortiz 2011).

In addition, one of the fundamental aspects of the medical sciences' Human Anatomy is the criticisms based on the little clinical relevant aspects (Frenk et al., 2011). Being in macroscopic Anatomy is a traditional transmissive rote teaching method. Learning has been understood as a generative process whose evaluation focuses on measurement. This method demands a pedagogical transformation that allows deep, comprehensive, and application-integrated learning and considers the learning process (Brunstein, 2014). Analyzing the history of medicine, centred on the anatomic study, the anatomist Andres Vesalio (1514-1564) was one of the founders of modern Anatomy and known for his great rigorous exposition. He was an innovator in teaching this subject, who experienced a Plague Pandemic that affected Padua (Italy), which permitted him to work with dissected corpses. This practice provided Vesalius with the dissection technique as a central activity of his classes and developed an anatomical-forensic update. At present, the teaching of Human Anatomy is carried out from the dissection completed with the observation of diagnostic images.

On the other hand, information and communications technology (ICT) has been used in the teaching-learning process, and they allow the visualization of different anatomical structures in their three-dimensional state. This procedure avoids using dissected corpses, which lowers cost and time. However, there are retractors of this technology's use, where it does not allow showing the complex reality of the human body (Rovetto, 2008). There are currently projects such as "Visible Human Project" developed in 1996 by the National Library of Medicine USA; complete and detailed anatomical three-dimensional illustrations of the human body (male, female) are found. This project provides cross-sections of the human body, obtained through computerized axial tomographic images and magnetic resonance imaging (National Library Medicine, 2019). Likewise, some universities work on simulators for the teaching of Human Anatomy, such as the so-called "Center for Human Simulation" at University of Colorado (Spitzer & Ackerman, 2008).

That is why there is a growing interest in modeling anatomical structures that allow different teaching-learning proposals in anatomy. That allows the improvement of understanding and learning, tiny and difficult to visualize structures. For authors such as Boza, Toscano, and Méndex (2009), the use of ITCs offers greater motivation in students, especially those with anatomical content (Salazar, 2011; Leiva and Mora, 2014). Furthermore, the teaching-learning practice improves with gamification that motivates and stimulates the student (Contreras & Eguia, 2016); both learning based on games (serious game) and augmented reality (Barma et al, 2015; Brown et al, 2020).

The epistemological perspective of augmented and virtual reality (VR) systems

It refers to the direct or indirect visualization of elements of the real world combined or augmented, linked with virtual elements generated on a computer, and from this fusion, mixed reality is offered (Cobo and Moravez, 2011: 105). From an educational perspective, authors such as Moreno-Martínez et al. 2016 and Philippe et al. 2020, define it as an emerging reality that allows the creation of mixed teaching-learning environments where virtual and real elements are combined. A wide number of works show how augmented reality reinforces learning and increases motivation to learn. Therefore, improving learning and discovery, providing the student with information that is easy to obtain that would otherwise be very difficult to obtain (Barr & Tagg, 1995; Reinoso, 2012; Hutson & Olsen, 2021; King & Smith, 2018; Kurilovas, 2014).

Augmented and VR provides immediacy and intuitive interactivity in student learning, which implies that the realization of teaching-learning activities becomes entirely practical activities. Thus, it eliminates the teacher's role, who is a proper transmitter at the same time, it eliminates the magisterial explanation and the mnemonic activity of the student without prior understanding. Also, augmented and VR are characterized by divergent cognitive development; that is, the student learns by doing and proposing different formulas for solving problems (Alper et al., 2021; Johnson & Westbrooks, 2021; Kozcu Cakir, Guven, & Celik, 2021; Moreno Martinez et al., 2016; Gandolfi, 2018, Philippe et al., 2020).

Although there are numerous studies on the benefit of using ICT and its promising future in teaching, it is necessary to know the capacities of the students and discuss whether the design of activities with VR can be beneficial. For this, models are used, such as the technology acceptance model, TAM (Technology Acceptance Model), to know if technology will be used optimally (Fathema et al., 2015; Scherer, et al., 2019). The TAM is one of the most widely used validated models to assess new technologies' level of acceptance. It extracts information of different dimensions: perceived utility (UP), perceived ease of use (FUP), perceived enjoyment, attitude towards use, and intention to use it (Cabrero and Pérez, 2018).

Objectives

The first objective was to know the degree of satisfaction or success of the group of students of the Human Anatomy subject about virtual and augmented reality. Moreover, to know the degree of technological acceptance by measuring the TAM instrument. The second objective was to determine if this emerging technology was an enriching experience by analyzing the satisfaction and usefulness of the students in the face of augmented and virtual reality. Moreover, validate the teaching-learning proposal by analyzing the acquisition of knowledge, content, and objectives of the study unit through the pretest and post-test comparative analysis.

Method

Samples of Study

The study was carried out in a secondary school in Andalusia (Malaga, Spain). Specifically, about the module of professional training studies of the health branch, the medium degree of nursing and health care. The total number of students in the study is 16 (in figure 1, the distribution of the sample is shown in the graphic). This study shows a semi-quantitative analysis of the TAM questionnaire to verify the degree of adaptation and acceptance of the augmented reality methodology to be used in this type of high school students The analysis of data was carried out using the Statistical Program GraphPad Prism 4, and also SPSS v 14. It was statistically significant the p-value <0.05.

Programming

For the Virtual Reality, was used the Students' mobile phones, viewers from Google Cardboard, and the Google Cardboard application, developed by Google, synchronized the viewer with the Smartphone. It works for Android or IOS operating systems (Dougherty, 2015; Brown and Green, 2016). The work plan carried out focused on five sessions. In the first session, an adaptation to VR of the TAM questionnaire was passed, which included two dimensions: UP and FUP. The UP was aimed at knowing if the subject thought that VR Systems could contribute or not to improve their performance. The FUP was designed to measure the degree of ease that VR Systems use could entail. In order to apply the TAM model and to adapt the scale, the Likert scale was used, made up of seven levels of importance: from "extremely disagree" to "extremely agree".

A pre-test was also passed to assess the previous contents, and brainstorm was carried out. When the next two sessions, lectures were given. In the fourth session, the Augmented and VR practice was carried out. Google viewers, smartphones, internet connection, and the "Sketchfab" application were used (Garcia-Bonete; Jensen and katona, 2019). The students were divided into three groups and received instructions on the operation of the viewer, the content to be viewed, and a poster with QR codes to scan to download the necessary applications.

Finally, VR systems were assessed using the second part of the TAM questionnaire and a questionnaire to diagnose the quality of the objects observed during the activity. In the fifth session, the post-test was carried out to verify knowledge acquisition.

Formative Program

The training program lasted 12 hours in total, divided into five sessions (Figure 1). The first session was used to carry out a knowledge pre-test and brainstorming. Subsequently, the explanations on the didactic unit of heart anatomy, distribution, and histology were started.

In session 2, students are introduced to virtual reality, and the operating mechanism is explained to them; cooperative groups are organized to work on augmented reality activities. This class is dedicated to the practice of VR and its management using different examples so that students become familiar with the terms, with the software, and with the operating mechanism.

Session 3, VR is applied directly to the main anatomical topic taught in the class, the heart, the cardiovascular system.

Session 4 is divided into three days, and on those days, activities are scheduled to work on the cardiovascular and lymphatic system and the anatomical dissection of the heart. The activities are carried out in cooperative groups to improve student interaction and gamification. The last session is used to carry out the post-test.
Session 5 is dedicated to make a post-test about the knowledge acquired.

During the training program's execution, three e-rubrics are made using the co-Rubric software (https://corubric.com). This program allows for cooperative rubrics between students. The rubric designed is made up of 6 items destined to assess the ease of use of the resource presented by each group, the aesthetics of it and the poster shown, the quality of the explanation given by each group, the temporal organization, and the management and development of the session.

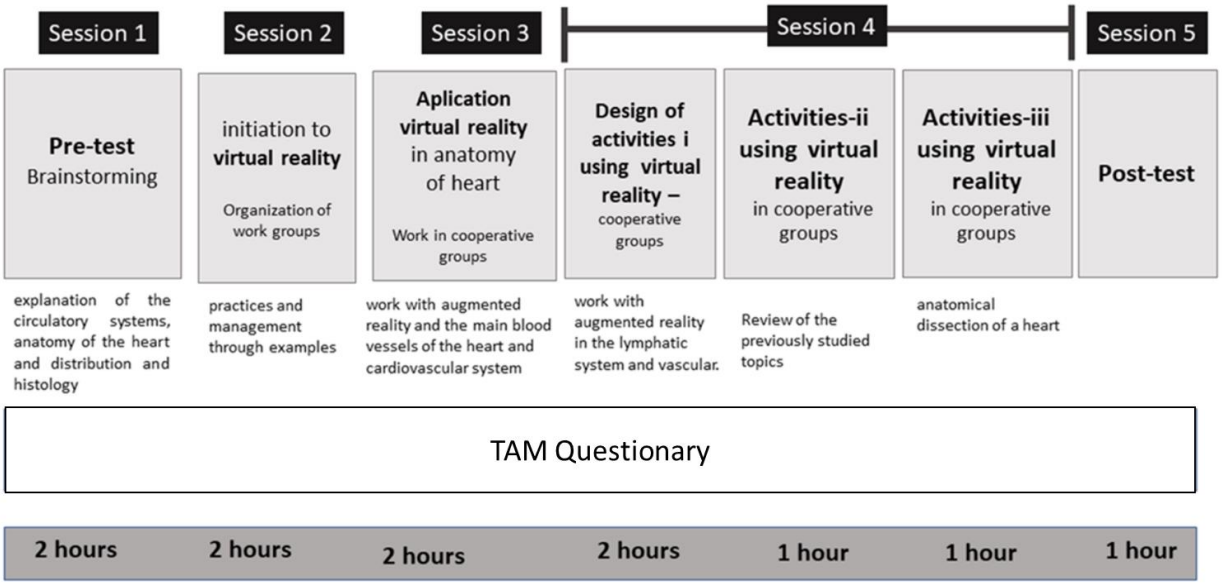

Figure 1. Formative Program

Results

Our results about the sample of the study's distribution have shown how the majority proportion of students are women (Figure 2). Related with the results involved of the perception of our students, specially how students recognize the usefulness of the system, how they consider its use useful, how they have enjoyed it, and if they

intend to use it in the future It was developed the figure 3, where the data shows the cumulative frequency (in percentage%) of the items evaluated in the satisfaction questionnaire on the augmented and VR resource used in the classroom. In general, the analyzed students showed high satisfaction in using these systems. The data reflect a very high statistical significance ($p < 0.001$) according to this system's use.

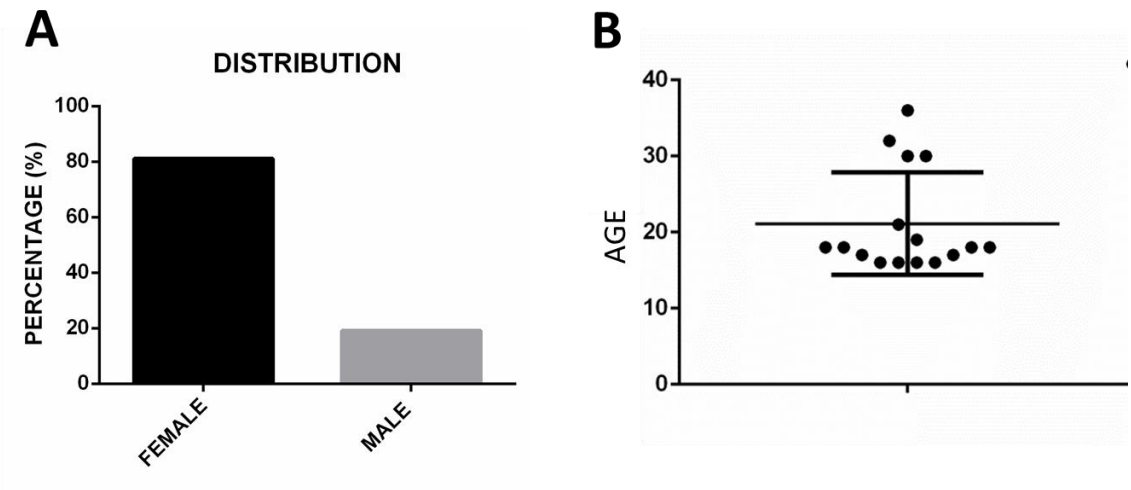

Figure 2. The graphic shows the distribution in the classroom. (A) represent the students samples evaluated in the study; (B) the mean age of the sample.

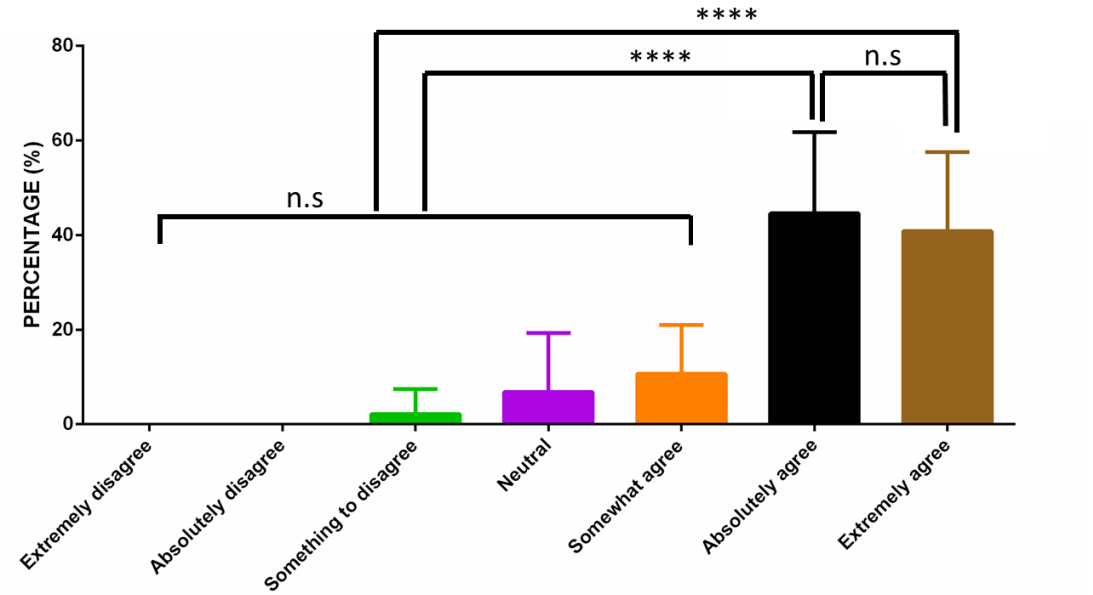

Figure 3. The figure shows the cumulative frequency (in percentage%) of the items evaluated in the satisfaction questionnaire on the augmented and VR resource used in the classroom. (The Analysis was performance using One-way ANOVA test, the statistical significance ***$p < 0.001$)

The analysis shows the comparison with the rest of the results. No significant (n.s) differences were found between the groups of samples extremely, absolutely, something disagree, neutra and somewhat agree; neither

between extremely and absolutely agree.

Results related to specific items evaluated in TAM score

The figure 4A shows how the students' perception, based on augmented reality, improved their learning by 60% concerning the students who are neutral or occasionally in agreement. The results related to the students' perception (see Figure 4B) about their improvement in learning using this method showed a comparable response among those who thought that they little agree (30%) and significantly agree (30%) with their improvement in knowledge performance.

However, the students' results (see Figure 4C) on whether they think that VR is useful for learning is the vast majority (above 50%) significantly agree with this opinion and a small minority (less than 2%) there is little agreement.

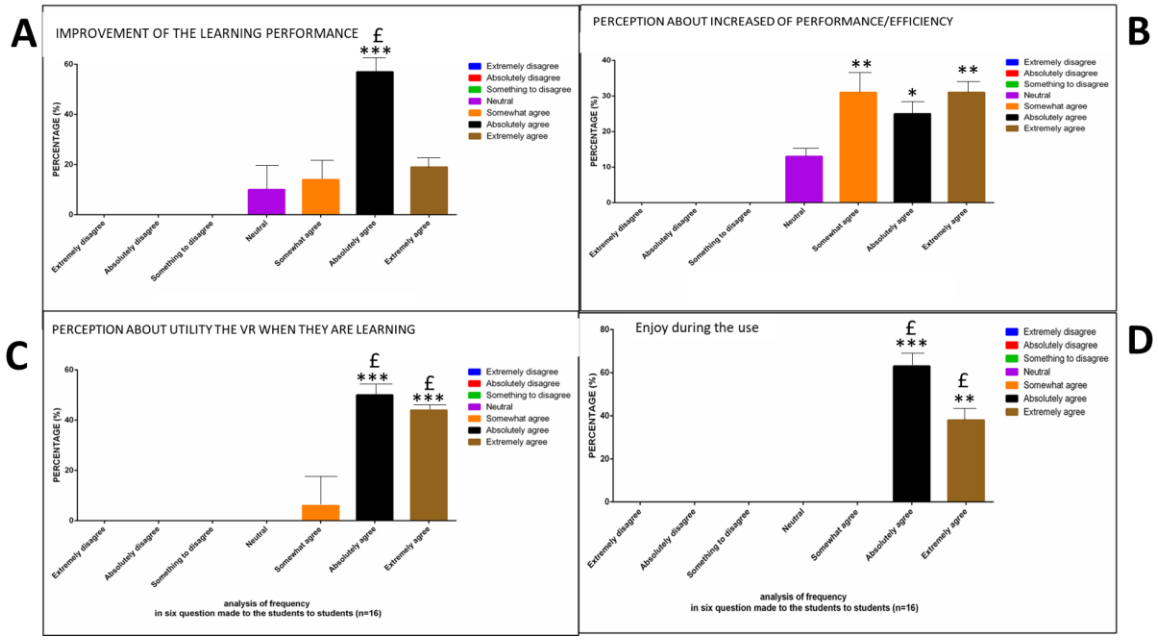

Figure 4. The graphics show the figure (A) Frequency analysis about the perception of utility using VR system in the improvement of the learning performance. (B) Frequency analysis about the usage of the VR System involved with the efficiency increases. (C) Frequency analysis about the usage of the VR System when the student is learning. (D) Frequency of the perception about enjoying during the use. The statistical analysis shows the differences between the groups with the neutral group (with symbol *) where it is represented as signification *p<0,05; **p<0,01; ***>p0,0001. And the comparison with the somewhat agree as a symbol £ represents signification as p<0,01.

The results obtained from the second part of the TAM and the quality diagnostic questionnaire (see Table 1) for augmented reality objects confirmed that the majority of the students enjoyed the experience. Regarding the

diagnosis of the quality of the objects observed in virtual reality, the majority of the student perceives in a positive way the aspects related to "technical and aesthetic aspects of the VR resource used" and "ease of use" (see Table 1).

Table 1. Results of the quality of the diagnostic instrument

(%) total amount	Operation of the application presented	Resource aesthetics	Technical function of the resource	Screen information rating	Ease of handling or use	Ease of understanding of technical handling
very positive	50	25	50	63	31	25
positive	50	75	50	31	50	69
indifferent	0	0	0	6	19	9
negative	0	0	0	0	0	0
very negative	0	0	0	0	0	0

Finally, the study shows how most students tend to strongly agree when considering that the tutorial of the program presented for VR offered information in an understandable and useful way and that this information made VR understandable and straightforward. From the results obtained in this preliminary study, it is observed that the implementation of VR presented in this training program was positive concerning the perceived experience. Therefore, we could consider that this resource has great potential for future interventions.

Results related to analysis of knowledge test: pretest and post-test

The post-test results show a significant improvement in knowledge acquisition compared to the pre-test. Associating all this result with the application of VR is not possible since it would have been necessary to use a second control group, where the VR application program had not been established to verify that the improvement in results is due to the use of of this technique. Indeed, this fact limits our study. Another progress that will be made shortly is the search for a more active role by the students, where they will be asked to be part of the design of virtual or augmented reality activities in future didactic interventions to involve them more in the contents of the subject considering the students as a more active part of the program.

The figure 5 shows the improvement of the knowledge acquired on the anatomical study when virtual and augmented reality has been used to study anatomical structures and the three-dimensional arrangement of organs. The analysis evaluates the grades from 0 to 10. The standards from 0 to 4 are considered inferior, from 5 to 6 sufficient, the 7 to 8 notable, and 9 to 10 outstanding. The results show a mean range of qualification in the pretest of 1.98 and later after applying the training program of 8.51, these data show a statistical significance of $p < 0.0001$ (analyzed by T-Student, see Table 3)

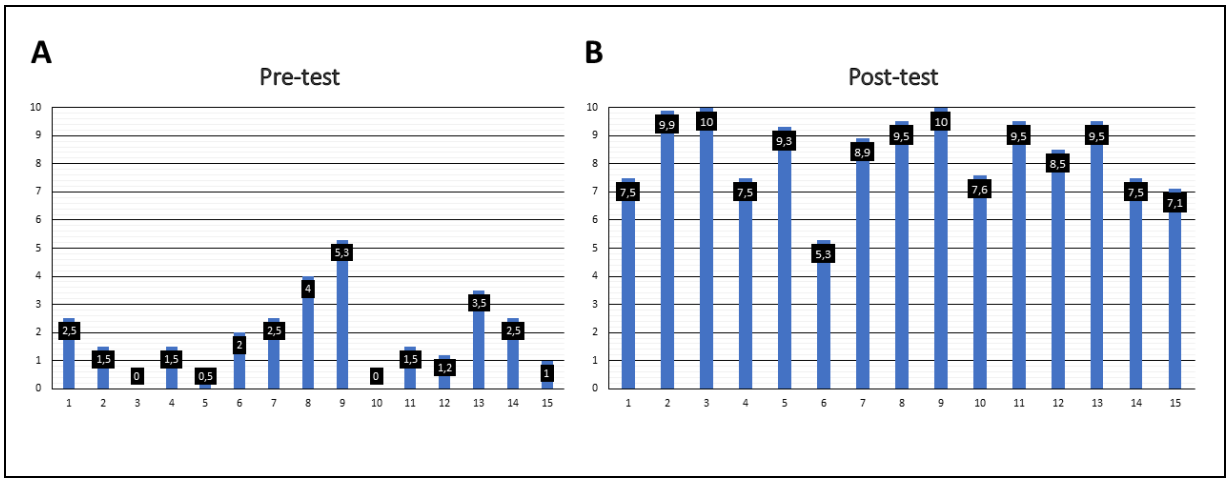

Figure 5. Results about (A) pre-test and (B) post-test related with 15 questions about the knowledge of anatomical structures and human anatomy.

Table 2. Statistical Analysis between the Pretest and Post-test

Paired Samples Test								
	Paired Differences							
	Mean	Standard Derivation	Error Derivation	95%Confidence Interval		t	gl	Signification
Pre vs Post - test	-6.540	1.7904	0.4623	Down (7.5315)	Up (-5.5485)	-14.148	14	0.0001

Discussion

In general lines, our students presented high satisfaction in the use of this technology in the classroom. The results obtained in the first part of the TAM questionnaire showed that the majority perceived VR as an easy-to-apply system that could facilitate understanding, learning, and performance. These results corroborate the study carried out by Iwanaga et al, 2021, where they show that during the time of the COVID Pandemic, the use of workspace in the classroom of Human Anatomy were very successful, it due to the advantages of the use of virtual and augmented reality in the context of confinement.

The results obtained in the second part of the TAM and the VR object quality diagnostic questionnaire confirmed that most of the students perceived VR as a fun system and a tool that they would like to use in future classes. Regarding the diagnosis of the quality of the objects observed in Virtual Reality, the majority positively perceived the technical and aesthetic aspects of the VR resource and the ease of use. Finally, the majority strongly agreed that the presented program guide offered useful and understandable information and that, in turn, it made the VR resource understandable and straightforward.

This methodology's versatile capacity was verified during this experimental development since the use of VR only required having a viewer, a smartphone, internet connection, and free applications (Molina-Carmona et al., 2018), which can be used in any high school. The results described, it can be deduced that both the TAM and the questionnaire that measured the quality of the objects shown in VR had a very positive result on the use of this tool. Besides, the study published by Poner et al., 2019 showed that the students' perception towards the use of VR was considered useful for Neuroanatomy Learning.

On the other hand, the post-test results showed a significantly improvement of knowledge, it could be indicating that VR for understanding and learning anatomical content could be beneficial. However, although the students' role has been active during the immersion experience in VR, it has not been so when searching and designing the VR activity. For this reason, in future interventions, it could be the students themselves in groups, the one in charge of searching and designing the VR activity.

Conclusion

We, in this preliminary study, can conclude from the results obtained that the use of VR for learning anatomical content has been very positive, especially when teaching is not face-to-face. This tool could be used as a resource with great potential for future interventions given the very positive experience shown by the students. It is necessary to carry out new research on the use of virtual reality, combining it with a greater involvement of students in the design and implementation of activities.

Recommendations

Given our experience in this field, we recommend the use of virtual and augmented reality for the study of forensic anatomical structures as a reasonable practice, which does not require dissection, which can be transferred to any secondary school, and which also improves student learning, without requiring a significant memory effort.

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References

Aguilar, M. (2012). Aprendizaje y Tecnologías de Información y Comunicación: Hacia nuevos escenarios educativos. *Revista Latinoamericana de Ciencias Sociales, Niñez y Juventud, 10*(2), 801-811.

Alper, A., Oztaş, E. S., Atun, H., Cinar, D., & Moyenga, M. (2021). A Systematic Literature Review towards the Research of Game-Based Learning with Augmented Reality. *International Journal of Technology in Education and Science (IJTES)*, *5*(2), 224-244. https://doi.org/10.46328/ijtes.176

Barma, S., Daniel, S., Bacon, N., Gingras, M. A., & Fortin, M. (2015). Observation and analysis of a classroom teaching and learning practice based on augmented reality and serious games on mobile platforms. International Journal of Serious Games, 2(2).

Barr, R. B., & Tagg, J. (1995). From teaching to learning—A new paradigm for undergraduate education. Change: The magazine of higher learning, 27(6), 12-26.

Boza, A., Toscano, M. y Méndez, J. M. (2009). El impacto de los proyectos TICs en la organización y los procesos de enseñanza aprendizaje en los centros educativos. *Revista de Investigación Educativa, 27* (1), 263-289.

Brown, A., & Green, T. (2016). Virtual reality: Low-cost tools and resources for the classroom. TechTrends, 60(5), 517-519.

Brown, B.A., Ribay, K., Perez, G., Boda, P.A., & Wilsey M. (2020). A Virtual Bridge to Cultural Access: Culturally Relevant Virtual Reality and Its Impact on Science Students. *International Journal of Technology in Education and Science (IJTES)*, *4*(2), 86-97.

Brunstein, J. (2014). Experiencias de los Académicos Acerca de Enseñar, Aprender y Evaluar Anatomía Humana. *Tesis Doctoral Pontificia Universidad Católica de Chile*.

Cobo, C., & Moravec, J. (2011). Introducción al aprendizaje invisible: la (r) evolución fuera del aula. *REencuentro. Análisis de Problemas Universitarios*, (62), 66-81.

Contreras, R. S. y Eguia, J. L. (2016). Gamificación en aulas universitarias. Bellaterra. Institut de la Comunicació, Universitat Autònoma de Barcelona. Pp. 8-10.

Dougherty (2015). Google intensifies focus on its cardboard VR device. Re- cuperado de https://www.nytimes.com/2015/05/29/technology/google-intensifies- focus-on-its-cardboard-virtual-reality-device.html.

Fathema, N., Shannon, D., & Ross, M. (2015). Expanding the Technology Acceptance Model (TAM) to examine faculty use of Learning Management Systems (LMSs) in higher education institutions. *Journal of Online Learning & Teaching*, *11*(2).

Frenk, J., Chen, L., Brhrutta, Z., Cohen, J., Crips, N., Evans, T., y otros. (2011). Profesoinales de la salud para el nuevo siglo: Transformando la eduación para fortalecer los sistemas de salud en un mundo interdependiente. *Revista Peruana de Medicina experimental y Salud Pública*, 337-341.

Gandolfi, E. (2018). VR and augmented reality. Handbook of Research on K-12 Online and Blending Learning, 545-561.

Garcia-Bonete, M. J., Jensen, M., & Katona, G. (2019). A practical guide to developing virtual and augmented reality exercises for teaching structural biology. Biochemistry and Molecular Biology Education, 47(1), 16-24.

Hutson, J. & Olsen, T. (2021). Digital Humanities and Virtual Reality: A Review of Theories and Best Practices for Art History. *International Journal of Technology in Education (IJTE)*, *4*(3), 491-500. https://doi.org/10.46328/ijte.150

Iwanaga, J., Kamura, Y., Nishimura, Y., Terada, S., Kishimoto, N., Tanaka, T., & Tubbs, R. S. (2021). A new option for education during surgical procedures and related clinical anatomy in a VR workspace. Clinical Anatomy, 34(3), 496-503.

Johnson, K. L., & Westbrooks, K. (2021). Quelling the Boredom with Alternative Instruction: Augmented Reality, Escape Kits, and Scavenger Hunts. *International Journal on Social and Education Sciences (IJonSES), 3*(1), 180-196. https://doi.org/10.46328/ijonses.65

King, B. & Smith, C.P. (2018). Mixed-reality Learning Environments: What Happens When You Move from a Laboratory to a Classroom? *International Journal of Research in Education and Science (IJRES), 4*(2), 577-594. DOI:10.21890/ijres.428961

Kozcu Cakir, N., Guven, G., & Celik, C. (2021). Integration of Mobile Augmented Reality (MAR) Applications into the 5E Learning Model in Biology Teaching. *International Journal of Technology in Education (IJTE), 4*(1), 93-112. https://doi.org/10.46328/ijte.82

Kurilovas, E., Juskeviciene, A., Kubilinskiene, S., & Serikoviene, S. (2014). Several semantic web approaches to improving the adaptation quality of virtual learning environments. J. UCS, 20(10), 1418-1432.

Leiva, V. y Mora, E. (2014). Aplicación de la tecnología de la información y comunicación en la enseñanza de anatomía para estudiantes de enfermería. *Revista de Enfermería Actual de Costa Rica, 26*. 1-13.

Martínez, N. M. M., & López, J. L. O. (2016). Herramientas y propuestas de innovación basadas en la tecnología de realidad aumentada aplicadas a la literatura infantil y juvenil/Tools and proposals for innovation based on augmented reality technology applied children's literature. *Tejuelo, 25*, 217-244.

Martínez, N. M. M., Olivencia, J. J. L., & Terrón, A. M. (2016). Mobile learning, Gamificación y Realidad Aumentada para la enseñanza-aprendizaje de idiomas. *IJERI: International Journal of Educational Research and Innovation*, (6), 16-34.

Miguélez-Juan, B. (2018). El uso de realidad virtual en la formación secundaria postobligatoria: aplicación en el bachillerato artístico. In U. Garay-Ruiz, E. Tejada-Garitano, y C. Castaño-Garrido (Eds.), *Uso de nuevas tecnologías y tendencias ac tuales en Educación* (pp. 54-61). Bilbao: Universidad del País Vasco/Euskal Herriko Unibertsitatea, Servicio Editorial.

Minguélez-Juan, B., Núñez, P. y Mañas-Viniegra, L. (2019). La Realidad Virtual Inmersiva como herramienta educativa para la transformación social: Un estudio exploratorio sobre la percepción de los estudiantes en Educación Secundaria Postobligatoria. *Aula abierta, 48* (2), 157-166.

Molina-Carmona, R., Pertegal-Felices, Ma. L., Jimeno-Morenilla, A., & Mora-Mora, H. (2018). VR learning activi- ties for multimedia students to enhance spatial ability. *Sus- tainability, 10*(4), 1-13. Recuperado de: https://doi.org/10.3390/su10041074

National Library Medicine. (8 de Julio de 2019). *U.S. National Library Medicine*. Recuperado el 30 de Diciembre de 2019, de https://www.nlm.nih.gov/research/visible/visible_human.html

Olivencia, J. J. L., & López, E. A. (2013). La "digiculturalidad" o la interculturalidad a través de las TIC: una tendencia emergente de e-learning humanizador. *Migramos a una Nueva Plataforma<, 13*(1).

Ortiz, A. (2011). Diseño y elaboración de materiales didácticos. In *Procesos educativos con TIC en la Sociedad del Conocimiento* (pp. 153-162). Pirámide.

Philippe, S., Souchet, A. D., Lameras, P., Petridis, P., Caporal, J., Coldeboeuf, G., & Duzan, H. (2020).

Multimodal teaching, learning and training in virtual reality: a review and case study. VR & Intelligent Hardware, 2(5), 421-442.

Ponte, R. P., Sanders, L. L. O., Júnior, A. P., Kubrusly, M., & Marçal, E. (2019). Development and Usability Assessment of a Mobile Application for Neuroanatomy Teaching: A Case Study in Brazil. Creative Education, 10(03), 600.

Raúl Reinoso (2012). Posibilidades de la realidad aumentada en educación. En *Tendencias emergentes en educación con TIC*. Espiral, 2012. p. 175-197.

Rovetto, P. (2008). *Ideas médicas: Una mirada histórica.* Cali: Universidad del Valle.

Salazar, J. (2011). Estado actual de la web 3.0 o web semántica. *Revista Digital Uni- versitaria,12*(11), 1-7.

Scherer, R., Siddiq, F., & Tondeur, J. (2019). The technology acceptance model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. *Computers & Education*, *128*, 13-35.

Spitzer, V. M., & Ackerman, M. J. (2008). The Visible Human® at the University of Colorado 15 years later. *Virtual Reality*, *12*(4), 191-200.

Torres Santomé, J. (2015). Organización de los contenidos curriculares y relevancia cultural. En S. Gimeno, *Los contenidos. Una reflexión necesaria* (págs. 91-102). Madrid: Morata.

Universtity of Colorado. (s.f.). http://www.ucdenver.edu/academics/colleges/medicalschool/centers/HumanSimulation/Pages/Home.asp