

Academic Stress Assessment Using Virtual Reality as an Educational Tool in Spine Surgery

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Abstract

Introduction: The evaluation of academic stress in medical students and residents is a topic of significant interest, given the considerable challenges they face during their learning process with traditional teaching methods. The use of technologies like virtual reality presents an opportunity to enhance their skills through simulations and training. The main objective of this study is to qualitatively assess the stress levels experienced by medical students and residents by integrating virtual reality into their current learning methods, aiming to improve their ability to manage stressors in their practice. **Material and Methods:** A questionnaire was conducted with 12 medical students and 12 Traumatology and orthopedics residents. The purpose of the questionnaire was to evaluate the levels of academic stress using the SISCO inventory. The stress levels were calculated by transforming average values into percentages, and the following criteria were assigned: 0 to 33% for Mild Stress, 34 to 66% for Moderate Stress, and 67 to 100% for Deep Stress. Then, a virtual reality class focused on spine surgery was provided. Both medical students and residents were trained using the Non Nocere SharpSurgeon software platform and Oculus Quest 2 virtual reality glasses. At the end of the session, a second questionnaire related to the practice with virtual reality was conducted with the same evaluation criteria and a comparative analysis was carried out. **Results:** 12 undergraduate students from Hospital Angeles Mexico, CDMX and 12 traumatology and orthopedics residents at Hospital Santa Fe, Bogota were evaluated. The students in CDMX reported an average qualitative stress of 28.50% during habitual practices, which decreased to an average of 14.67% after virtual reality practice. Residents in Bogotá experienced an average qualitative stress of 30.50% with their current learning methods but this reduced to an average of 13.92% after using virtual reality. These findings indicate that

the use of virtual reality has a positive impact on reducing stress levels qualitatively. **Conclusions:** The use of virtual reality as a learning method for medical students and residents qualitatively improves stress levels. Further studies are required to define the potential uses of Virtual Reality to improve learning methods and emotional state in medical students and residents and for a quantitative assessment to validate the training as certified learning methods.

Keywords

Virtual Reality, Academic Stress, Learning Strategies, Spine Surgery Training

1. Introduction

Academic stress in medical students is a topic of great relevance as they experience high demands and intense emotional burden due to working life or death situations. They are known to face high levels of stress and anxiety due to the challenges and pressure to obtain good results in their training, lack of time, competition among peers, personal problems, among others [1]. These factors can trigger responses that impact physical and mental health, such as depression and other disorders that compromise their academic performance [2].

In order to uphold professionalism and achieve excellence in any field, it is essential to undergo extensive and rigorous training. This training should not only focus on acquiring knowledge but also emphasize the importance of actively sharing and transmitting that knowledge [3]. It should be conducted in a directed manner, ensuring that specific learning objectives are met. Furthermore, the training should be reproducible, meaning that others can replicate the process to obtain similar results. Lastly, a comprehensive approach should be adopted, covering all relevant aspects of the subject matter to ensure a well-rounded understanding.

The integration of virtual reality technology as a teaching tool in medical education has shown remarkable benefits, particularly in the area of stress management for students. By immersing themselves in virtual environments, medical students are provided with realistic scenarios that simulate real-life patient interactions, medical procedures, and challenging situations. This immersive experience allows them to practice critical decision-making skills in a controlled and safe environment. Research studies have consistently shown that utilizing virtual reality as a teaching tool not only enhances stress management for medical students but also leads to a significant improvement in the overall quality of their education. The ability to experience and navigate complex medical scenarios virtually helps students develop crucial skills such as clinical reasoning, teamwork, communication, and empathy. Furthermore, virtual reality-based training offers numerous advantages over traditional teaching methods. It provides an interactive learning experience that engages multiple senses, resulting in

better retention of knowledge. Students can actively participate in simulations that closely resemble real-world clinical settings without any risk to patients or themselves. Moreover, incorporating virtual reality into medical education promotes inclusivity and accessibility. Students who may not have access to certain resources or opportunities can now benefit from immersive learning experiences regardless of their location or financial constraints.

When incorporating new technologies in the field of education, there are several important objectives to consider. One of these objectives is to facilitate the acquisition of knowledge, as technology can provide students with access to a vast amount of information and resources that can enhance their learning experience. Additionally, new technologies can aid in decision making by providing students with interactive platforms and simulations that allow them to practice critical thinking and problem-solving skills. This not only improves their decision-making abilities but also prepares them for real-world scenarios. Furthermore, integrating technology into education has the potential to improve various skills. For instance, students can develop digital literacy skills by using different tools and applications. They can also enhance their communication and collaboration skills by working in teams through online platforms. Lastly, new technologies can be used to evaluate teachers performance and modify teaching methods accordingly. By leveraging data analytics and feedback systems, educational institutions can gain insights into how effective certain teaching strategies are and make adjustments to ensure a more modern and useful medical education. In summary, incorporating new technologies in education serves multiple objectives including facilitating knowledge acquisition, enhancing decision-making skills, improving various competencies such as teamwork [4], and enabling evaluation of teaching methods for more effective medical education.

The integration of immersive and multisensory experiences in educational settings has been widely acknowledged as a highly effective method to simplify the complexity of various subjects. By adopting this approach, educators are able to adapt any type of teaching material, including distance education and virtual classrooms, to provide a more engaging and interactive learning environment. Research indicates that incorporating immersive technology not only enhances students' understanding and retention of information but also has a positive impact on their emotional well-being. In today's world, where feelings of loneliness and depression among students are prevalent, these experiences can serve as a valuable tool in reducing such negative emotions. By creating a sense of presence and connection within the virtual learning space, students are able to feel more connected to their peers and instructors, thus combating feelings of isolation. Furthermore, the incorporation of multisensory elements in these experiences allows for a more holistic learning approach. Engaging multiple senses simultaneously enables students to better comprehend complex concepts by appealing to different learning styles. Visuals, sounds, touch feedback, and even olfactory cues can be used strategically to create an immersive environment that caters to individual preferences. Overall, the utilization of immersive and multi-

sensory experiences in education not only simplifies the understanding of challenging subjects but also addresses mental health concerns by fostering social connectedness among students. As technology continues to advance, it is expected that these approaches will further revolutionize teaching methods and contribute significantly towards creating an inclusive and effective learning experience for all learners.

Virtual reality (VR) is an advanced technology that provides users with the unique opportunity to immerse themselves in a computer-generated virtual world in real-time. By incorporating specialized hardware and software, VR creates a simulation of an artificial environment that can encompass various elements such as stunning 3D graphics, realistic sound effects, and even haptic feedback for enhanced sensory experiences. With VR, users can engage with the virtual environment in a highly interactive manner, allowing for unprecedented levels of engagement and exploration. This groundbreaking technology has opened up endless possibilities across industries, from entertainment and gaming to education and training. By transporting users into digital realms that feel incredibly lifelike, virtual reality has revolutionized the way we perceive and interact with computer-generated content [5] [6] [7].

Virtual reality in medicine offers numerous benefits. It enables unlimited practice sessions, regardless of location or time, without posing any risk to patients. This safe, controlled, and cost-effective environment can be a powerful tool for reducing stress and enhancing academic performance among students. Therefore, it's an effective strategy that combines technology with education for improved outcomes.

Today, the application of virtual reality in education presents a unique opportunity for students across various disciplines, particularly in surgical practices. It provides them with a platform to encounter diverse scenarios involving anatomical variations or emergencies. This innovative approach enhances their abilities and highlights their skills, thereby improving their overall training experience.

The immense potential of virtual reality in the field of medical education is set to have a profound impact and gain wider acceptance. As it becomes a standard teaching method for both educators and students, it can significantly reduce errors, thereby enhancing patient safety [8]. This improvement in healthcare delivery can lead to better stress management and consequently, improved academic performance among students.

There are some scales, among them the “SISCO Academic Stress Inventory” [9] which is a self-report instrument that assesses psychological and behavioral reactions related to academic stress. It allows evaluating the level of stress, as well as the frequency in which the environment is valued as a stressful stimulus. Additionally, it helps in identifying the symptoms or reactions to these stimuli and the strategies to face them [10] [11].

The VR-powered surgery education platform, SharpSurgeon, allows students to learn from actual cases and practice surgical techniques. This platform also

enables immediate questions, corrections, and real-time observation. 3D models are generated using actual images data from real patients, providing users with an authentic view of a human body for teaching and learning surgery. The interactive platform allows users to learn the principles of surgery and review anatomy. Additionally, learners have access to peer-to-peer discussions and insightful feedback from educators. This helps them take their surgical skills to the next level while educators enjoy unprecedented control over the learners learning curve [12].

By examining the two distinct learning modalities, we can gain valuable insights into the potential benefits and drawbacks of incorporating virtual reality into medical education. Furthermore, this research seeks to contribute to the ongoing development and application of virtual reality techniques in medical education. By exploring the impact of virtual reality on stress levels, we can identify areas where it may enhance current educational practices.

2. Hypothesis

The use of virtual reality as a learning method for medical students will qualitatively improve stress levels and enable better management of stressors in their academic practices.

3. Material and Methods

The primary objective of this study is to conduct a comprehensive qualitative evaluation of the stress levels experienced by medical students. Specifically, we aim to compare their experiences with traditional learning methods and the use of virtual reality as an innovative approach.

A background search was conducted to evaluate academic stress qualitatively, as well as teaching studies in spinal surgery using virtual reality methods.

Doctors who were taking the Spine Module at Hospital Angeles Mexico, CDMX, and residents in Traumatology and Orthopedics at Hospital Santa Fe, Bogota, were invited to participate. They were provided with a questionnaire based on the evaluation of the SISCO Inventory of academic stress.

3.1. Inclusion Criteria

Doctors who were taking the Spine module in their training and residents in Traumatology and orthopedics who wish to participate in the study.

3.2. Exclusion Criteria

Doctors who do not wish to participate in the project. Doctors do not complete more than 70% of the questionnaires.

3.3. Methods

To evaluate the SISCO questionnaire, each response was assigned a value based on the following scale: 0 for “never”, 1 for “rarely”, 2 for “sometimes”, 3 for “al-

most always” and 4 for “always”. The average score was calculated for each item and then an overall average was obtained. This average was then converted into a percentage. Based on this percentage, the following criteria were applied: scores ranging from 0% to 33% were classified as Mild Stress, scores ranging from 34% to 66% were classified as Moderate Stress, and scores ranging from 67 to 100% were classified as Deep Stress.

A 30-minute session was conducted using Oculus Quest 2 virtual reality glasses to interactively train doctors. The session featured 3D cervical spine models of a real patient, and the training utilized NonNocere’s SharpSurgeon software platform. At the end of the session, a second questionnaire was administered, based on the evaluation of the SISCO Inventory of academic stress. The questions in this second questionnaire were specifically related to practicing with virtual reality and followed the same evaluation criteria as before, assigning a percentage and level of stress.

To determine the validity of the results, questionnaires that had more than 70% of the questions answered were taken into consideration. A database was obtained with the percentages of stress according to each item, and the comparative analysis was carried out.

There were no disclosures for this study. Data was collected in accordance with the Declaration of Helsinki, which ensures ethical guidelines for medical research. The data collection process was completely voluntary and anonymous, meaning that participants’ identities were protected. In terms of equipment, Oculus Quest 2 virtual reality glasses and NonNocere’s software were sponsored by Globaltech, a distributor in Mexico. This sponsorship aimed to promote the use of the platform in the field of spine surgery. It is important to note that no charges or payment were imposed on any participant involved in the study.

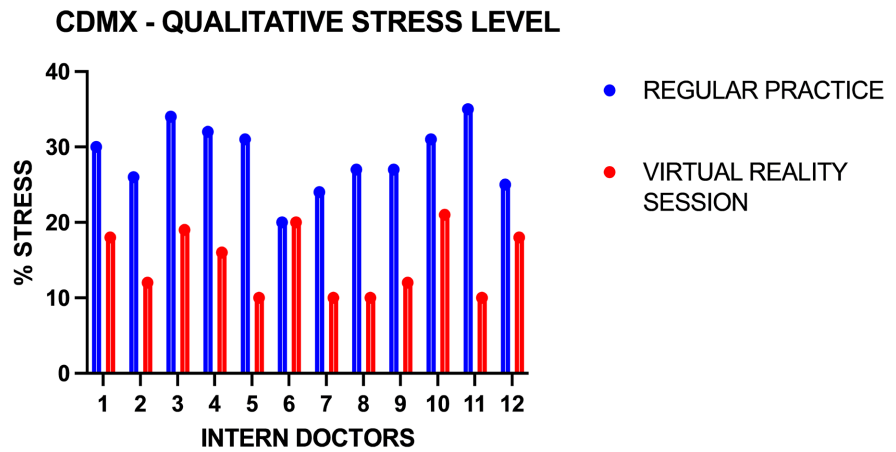
4. Results

12 undergraduate intern doctors from Hospital Angeles México were evaluated. Out of these, 91.6% (11 interns) reported experiencing moments of worry and nervousness in the last 6 months of their internship with conventional learning methodologies. However, after participating in a virtual reality session, only 16.6% (2 interns) reported feeling worried or nervous (**Graph 1**).

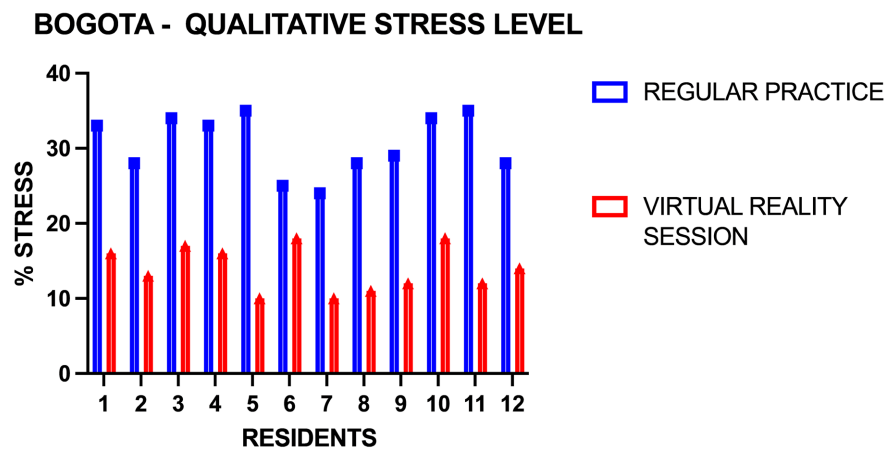
Prior to the virtual reality practice, the average qualitative stress level was measured at 28.50%. After the virtual reality practice, this average decreased to 14.67%.

At the Santa Fe Hospital in Bogotá, 12 traumatology and orthopedics resident doctors were evaluated. Out of these, 50% (6 residents) reported experiencing moments of worry and nervousness in the last 6 months. They also reported a moderate stress level (greater than 33%) associated with practices involving conventional learning methodologies (**Graph 2**).

After virtual reality practice, the average qualitative stress decreased from 30.50% to 13.92%.



Graph 1. Qualitative stress level in each student evaluated before and after virtual reality practice.



Graph 2. Level of qualitative stress in each resident of Bogotá evaluated before and after the virtual reality practice.

There are no significant differences at stress levels between groups. However, there was a significant reduction in stress levels before and after virtual reality practice for both groups. Additionally, an improvement was observed in the group of residents compared to the undergraduate group in terms of their scores related to the use of strategies to cope with stressful situations.

5. Discussion

The validation process for the use of virtual reality in learning programs and teaching methodologies within the medical field involves several steps. First, it's crucial to identify specific educational objectives that can be enhanced through virtual reality. Next, a comprehensive review of available VR technologies should be conducted to determine which ones best meet these objectives. Following this, a pilot program should be implemented to test the effectiveness of chosen VR tools in achieving desired learning outcomes. Feedback from both educators and learners is then used to refine and optimize the VR-enhanced curriculum. Final-

ly, ongoing evaluation is necessary to ensure that the use of VR continues to add value over time and adapt as technology evolves.

This research specifically assesses how the utilization of virtual reality tools can contribute to enhancing the emotional well-being of medical students. By employing these cutting-edge technologies, educators are able to diversify their teaching and learning methodologies, resulting in a more immersive and engaging educational experience for students. As a result, medical students can not only gain valuable knowledge but also experience a significant improvement in their emotional well-being throughout their academic journey.

An interdisciplinary project has been proposed involving collaborators and students from two Latin American cities, Bogotá and Mexico City. This proposal is based on the observation that the teaching methodologies used so far are not distinct between both groups, nor are the teaching objectives different in terms of applying new methods. By implementing this interdisciplinary project, it is expected to bridge the gap between teaching methodologies and objectives in any country, ultimately leading to a more diverse and effective educational experience for both collaborators and students.

The objective of conducting this study on various undergraduate and graduate students, who experience different types of stress, is to validate that the use of technology can effectively reduce stress levels. Even in a short class and with a small sample size, both groups managed to improve their stress levels.

The findings from this study suggest that integrating technology into classroom settings can effectively decrease stress levels among undergraduate and graduate students, leading to increased enthusiasm for future sessions and improved academic performance.

The interest and ease of adaptation of medical students and residents in the use of virtual reality glasses has recently garnered significant attention. It is noteworthy that even those who had not previously experienced such technology showed enthusiasm in embracing it. This remarkable response reflects the immense potential that virtual reality platforms hold for future generations in the field of medicine. With these innovative tools, medical professionals can immerse themselves in realistic scenarios, enhancing their learning experiences and improving patient care outcomes.

The technology discussed in this text presents numerous advantages for students. By allowing for repeated usage, it has the potential to alleviate stress levels and enhance learning outcomes. Additionally, it empowers students to engage in comprehensive practice sessions that cover a wide range of topics, from basic anatomy principles to simulations and preoperative planning. This continuous exposure and practice can greatly contribute to their overall comprehension and expertise in these areas. Overall, this technology holds immense potential for improving educational experiences and outcomes for students.

One of the primary limitations for the widespread use of these technologies lies in the accessibility of virtual reality glasses. While the technology itself has made significant advancements, it is still not widely available to everyone.

Another important aspect is the development of compatible software and teaching platforms. While these can be reused for multiple classes, there is a requirement for programming each clinical case individually, which can be time-consuming and resource-intensive.

6. Conclusions

The incorporation of virtual reality technology as a teaching tool has proven to be highly beneficial for medical students. It not only enhances their stress management capabilities but also contributes to an overall improvement in the quality of their education by providing realistic scenarios and promoting active learning. As technology continues to advance, the potential for further advancements and applications within the field of medical education is truly exciting.

Additional research is necessary to determine the potential applications of Virtual Reality in enhancing learning techniques and quantitatively evaluate the learning progress of medical students, and for example, in spine surgery to evaluate doctors while placing screws and performing spinal decompression techniques.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

- [1] Barteit, S., Lanfermann, L., Bärnighausen, T., Neuhann, F. and Beiersmann, C. (2021) Augmented, Mixed, and Virtual Reality-Based Head-Mounted Devices for Medical Education: Systematic Review. *JMIR Serious Games*, **9**, e29080. <https://doi.org/10.2196/29080>
- [2] Barsom, E.Z., Graafland, M. and Schijven, M.P. (2016) Systematic Review on the Effectiveness of Augmented Reality Applications in Medical Training. *Surgical Endoscopy*, **30**, 4174-4183. <https://doi.org/10.1007/s00464-016-4800-6>
- [3] Moro, C., Birt, J., Stromberga, Z., Phelps, C., Clark, J., Glasziou, P., *et al.* (2021) Virtual and Augmented Reality Enhancements to Medical and Science Student Physiology and Anatomy Test Performance: A Systematic Review and Meta-Analysis. *Anatomical Sciences Education*, **14**, 368-376. <https://doi.org/10.1002/ase.2049>
- [4] Kamphuis, C., Barsom, E., Schijven, M. and Christoph, N. (2014) Augmented Reality in Medical Education? *Perspectives on Medical Education*, **3**, 300-311. <https://doi.org/10.1007/S40037-013-0107-7>
- [5] Luciano, C.J., Banerjee, P.P., Bellotte, B., Oh, G.M., Lemole, M., *et al.* (2011) Learning Retention of Thoracic Pedicle Screw Placement Using a High-Resolution Augmented Reality Simulator with Haptic Feedback. *Neurosurgery*, **69**, ons14-ons19. <https://doi.org/10.1227/NEU.0b013e31821954ed>
- [6] Alaraj, A., Luciano, C.J., Bailey, D.P., Elsenousi, A., Roitberg, B.Z., Bernardo, A., *et al.* (2015) Virtual Reality Cerebral Aneurysm Clipping Simulation with Real-Time Haptic Feedback. *Neurosurgery*, **11**, 52-58. <https://doi.org/10.1227/NEU.0000000000000583>

- [7] Guze, A.P. (2015) Using Technology to Meet the Challenges of Medical Education. *Transactions of the American Clinical and Climatological Association*, **126**, 260-270.
- [8] Bonk, C.J. (2009) *The World Is Open: How Web Technology Is Revolutionizing Education*. Jossey-Bass, San Francisco, CA.
- [9] Macías, A.B. (2007) Inventario SISCO del estrés académico. Propiedades psicométricas. *Terapia psicológica*, **40**. <http://dx.doi.org/10.4067/S0718-48082022000200197>
- [10] Lifshitz, G.A. (2012) La enseñanza de la clínica en la era moderna. *Investigación en Educación Médica*, **1**, 210-217.
<https://doi.org/10.22201/fm.20075057e.2012.04.00008>
- [11] Ramírez, A.J., Rodríguez, W.F. and Ocampo, L.R. (2018) La educación médica para las últimas generaciones. *Acta Médica Grupo Ángeles*, **16**, 267-270.
- [12] <https://nonnocere.de/sharpsurgeon/>.

Abbreviations and Acronyms

3D: three dimensional. SISCO: cognitive systemic inventory.