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The Role Of Virtual Reality In Dental Education And Training

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Abstract

Virtual reality and active digital models have been increasingly used in dentistry education to provide dental students with training prior to their engagement with actual patients. The employment of virtual tools in dentistry education has been supported by scientific data. Recent articles have shown that virtual and tactile technologies may provide favorable results in dental education. The objective of this systematic review was to assess the impact of virtual technologies on dental education outcomes and toinvestigate the perspectives of dental students and instructors on these technologies. A comprehensive search was performed in PubMed, Scopus, MEDLINE (via EBSCO), The Cochrane Library (via Wiley), Web of Science Core Collection (via Thomson Reuters), and Dentistry and OralScience source (via EBSCO) using the keywords "student" and"dental" in conjunction with "education" and "dental," as well as "virtual reality," "augmented reality," "haptics," "simulation," "dentistry," and "dental medicine." The assessment of the submitted information's quality was conducted in accordance with the guidelines outlined in the Recommended Reporting Items for Systematic Review and Meta-Analysis (PRISMA) statement for systematic reviews. For this study, a grand total of 73 publications were taken into account. Out of the chosen research, fifty-two demonstrateda noteworthy improvement in educational results, and virtual technologies were universally regarded favorably by all participants. Based on the constraints of this review, it seemsthat virtual technology enhances educational achievements among dentistry students. Additional research with bigger sample sizes and longer duration clinical trials is necessary to

validate the potential beneficial effects of different virtual technologies on dentistry education outcomes.

Keywords: augmented reality, simulation, dentistry education, haptics, students, virtual reality, education.

1. Introduction

Virtual reality (VR) simulations have been used in dental education in addition to traditional skill training to prepare dental students for real patient interactions. Dental education is unique because it involves theory, laboratory work, and clinical practice. The difficulty in dental education stems from the fact that acquiring theoretical knowledge necessitates spatial imagination, while traditional mannequin simulation training, which is patient-centered, does not accurately replicate real-life clinical scenarios.[1-4] Preclinical and clinical training are crucial for honing fine motor skills and preparing dental students for their future careers in dentistry. Acquiring the necessary skills for dental education is difficult and requires repeated training and extensive practice. However, the emergence of the novel coronavirus SARS-Co-V-2 in late 2019 has further complicated matters. To adhere to social distancing guidelines and prevent the gathering of students in enclosed spaces, traditional one-on-one dental teaching methods have been partially replaced by digital or virtual setups.[5-8]

Researchers were interested in the potential uses of VR in dental education, even during the initial experimental phases. It was proposed that VR could improve dental education compared to traditional teaching methods, particularly in the training of restorative dentistry and dental surgery. There is also the possibility of expanding its use to include endodontics and orthodontics. VR technology allows for the remote delivery of online lectures using a 3D VR workplace. The technology's adaptability enabled the participants to actively contribute and permitted a comprehensive comprehension of surgery and associated anatomy in 3D, despite technological challenges being a restriction. However, there is conflicting evidence about the usefulness of virtual reality (VR) in achieving desired goals in dentistry education. Therefore, this systematic study sought to assess the efficacy of virtual reality simulations in improving dental education results. The evaluated outcomes of VR treatments included knowledge,

clinical skills, attitude, and satisfaction of both learners and instructors.

2. Virtual Reality (VR)

Virtual Reality (VR) is increasingly recognized as a valuable training tool for dental students, and its adoption by dental schools is increasing globally. VR refers to a computer-generated simulation of a three-dimensional (3D) image or environment that utilizes software to create an immersive computer-generated setting. Users wear a head-mounted display that immerses them in a virtual environment, allowing them to interact with the surroundings and virtual characters in a realistic manner. Virtual reality (VR) has the potential to provide significant advantages in dentistry education by creating a training environment where patients may receive instruction without physical touch. This allows for a safer and more immersive learning experience.[9,10]

3. Augmented reality (AR)

Augmented reality (AR) is the process of overlaying computer-generated images onto a real-life situation. It contrasts with VR, since it does not accurately replicate real-world situations. Augmented reality (AR) is a technology that combines real and virtual elements to create a unified experience. It enables learners to visualize intricate spatial relationships, abstract concepts, and encounter phenomena that would otherwise be impossible in the real world, particularly in the context of surgical procedure coaching. Immersive virtual reality (IVR) is a type of AR where users engage with a digital 3D environment that is recreated using actual 360-degree recordings.[11,12]

Haptic technology, sometimes known as HT, is a modern kind of simulation that allows users to experience tactile sensations while interacting with computer-generated objects. Haptics refers to the perception of touch and involves the study of incorporating the interaction with the external environment through physical contact. The application of these technologies in dental education has inspired designers to develop virtual teeth that simulate various characteristics such as pathology, multiple layers, and different levels of mechanical hardness to enhance the realism of the experience.[13,14]

4. The use of virtual reality (VR) in dentistry education

The use of virtual reality (VR) in dentistry education has seen substantial growth, and there exists substantial scientific data that delineates various virtual configurations in diverse dental training modules. Nevertheless, the precise impact of VR simulation on dentistry education results remains uncertain. Previously, virtual reality (VR) may have been seen as a premium or discretionary choice. However, in light of the worldwide COVID-19 (coronavirus disease 2019) pandemic, dentistry students must continue with their curriculum without any hindrance caused by the necessity for physical presence. Virtual reality (VR) has the potential to allow dentistry students to develop and maintain their theoretical and clinical dental skills from a distant location.[15-18]

This comprehensive study demonstrated that virtualreality (VR) greatly improved the development of dental manual skills, even with brief training sessions. Additionally, it had a somewhat weaker effect on the retention of theoretical information. Although a limited number of studies have provided extended durations of follow-up, they have shown no significant differences between virtual and conventional groups.[19-22]

The variability in students' learning styles and motivation is a significant obstacle for course designers. Integrating virtual simulators into the dental curriculum and using their data to categorize dental students and forecast their clinical performance would enable customization of the learning process to accommodate the diverse expertise of individual students and allow them to progress at their own speed. Within this particular setting, the dentistry curriculum has the potential to provide an educational experience that enables every student to achieve their highest level of performance.[23-26]

The review identified five main areas of significance: the versatility of VR applications and their varying use in different dental disciplines, the widespread use of HT in dental education, the development of virtual dental patients to enhance dental education, the importance of digital real-time feedback, and the accessibility of virtual technology for students.

Initially, virtual reality (VR) has been utilized in dental education with a diverse array of devices and technologies. These include VR simulations with or without an immersive

environment, haptic simulators with or without force feedback, augmented reality (AR) devices, real-time digital mapping and evaluation, virtual mobile platforms, video games, and other virtual packages. The wide range of specific characteristics highlights the absence of established educational benchmarks for dental simulators or related activities. Moreover, there is uncertainty regarding the impact of the varying reliability of simulator systems on the outcomes of dental education. This review primarily focuses on the use of virtual reality (VR) in restorative dentistry, prosthodontics, and oral and maxillofacial surgery, considering the intricate nature of the dental training required to achieve a high level ofclinical competence. However, there were a limited number of research that focused on pediatric dentistry, dental radiology, periodontology, and orthodontics. Restorative dental procedures may provide the opportunity to tailor the necessary duties to individual needs, while other dental specialties may need more customisation and expertise to meet the unique requirements of the field.[9]

Furthermore, this review demonstrated that HT was the predominant technology utilized, particularly in tasks involving drilling and tooth preparations, which aligns with the findings of Towers et al.[6] HT provides an extra level of immersion in virtual reality by incorporating the sense of touch and force feedback (FFB) to simulate the various layers of teeth and bone. Therefore, HT demonstrated its effectiveness in teaching hand-eye coordination and spatial reasoning abilities to inexperienced dentistry students. In addition, it enhanced students' ability to accurately prepare and reduced the time required for early-stage training. Furthermore, it enhanced a cautious approach to preparation. However, given the distinct nature of dental procedures, FFB should be enhanced and incorporated as a fundamental component in any educational dental simulator to improve the perception of tooth structure and various layers of bone. Training with FFB offers a heightened feeling of authenticity and enables the student to experience the sensation of an intrusive operation in a virtual learning setting.

Furthermore, Virtual Reality (VR) has shown extensive use in the field of dentistry education, effectively enhancing both the development of practical abilities and the acquisition of theoretical information. The use of virtual patients (VP) decreased the anxiety related to managing real patients and implementing a treatment plan. It provided students with an

interactive learning opportunity, enhanced their self-assessed competence, and increased their confidence in dealing with real patients. Simulators provide the advantage of time flexibility, enabling students to repeat procedures until they reach acceptable skill levels without putting real patients at risk or requiring prolonged direct contact. However, virtual patient (VP) simulators for dental training need further improvement to accurately simulate the oral environment, including gingival tissues, saliva, tongue movements, and reflexes such as gagging, coughing, and head movements. Consequently, it would be beneficial to educate emergency management in the dentistry context.

Furthermore, the use of virtual reality (VR) apps equipped with real-time dental teaching and assessment systems proved to be very advantageous in the development of motor skills in preclinical environments. The use of simulating devices provided immediate feedback on students' performance, improved their ability to assess themselves, and eliminated subjective evaluation. However, dental students expressed that the instructions and feedback from these devices should be supplementary to, rather than a substitute for, feedback from faculty members. Faculty members must diligently fulfill their duty to educate new dentists, while also providing care to patients with unique requirements. This includes demonstrating empathy and ensuring that informed permission is obtained for all treatment decisions. The faculty plays a crucial role as a role model when overseeing students in patient care in clinical settings, complicated problem-solving, comprehensive conceptual understanding, and peer interaction. Consistent training under the guidance and evaluation of professors is an essential aspect of quality dental education.

Furthermore, the majority of the research used virtual reality (VR) technology inside academic labs. This aspect warrants reevaluation, and it is imperative to explore the development of alternative mobile platforms. In order to take use of the technology, the student must be physically located on the academic campus. This condition significantly restricts the potential for maximizing the benefits of virtual technology owing to the compressed academic schedules and the additional training durations that are necessary. Curriculum planners should be aware that virtual programs on personal computers and mobile devices have the potential to shift the responsibility of the whole education process to the students.

Some students may be able to effectively manage their time in this scenario, while others may struggle. Therefore, it is essential for supervisors and teachers to closely oversee the learning process as a lack of motivation in certain students can diminish the advantages of technology. To address this, tutors should implement ongoing evaluation through methods such as spontaneous quizzes, group discussions, and scheduled assignments or presentations. This approach will ultimately result in a combination of traditional and technology-based learning, emphasizing the importance of the teacher's role.

According to the findings of this research, it is advised to make affordable virtual reality hardware and software easily accessible in order to provide secure and economical interactive educational training. This would enable learners and trainees to participate instantly via their personal computers or mobile devices. It is recommended to specify the learning materials and determine how much traditional processes should be taught, in addition to the virtual information. An instructional video game is a teaching approach that should be used more widely. This type of educational material heightened students' enthusiasm for learning and transformed the learning process into an enjoyable experience. Younger generations are particularly adept at embracing new technologies and are becoming increasingly familiar with video games, which further encourages the advancement and enhancement ofeducational methods that incorporate fun.

5. Conclusion

The use of advanced simulation technologies has enhanced the quality of results in dentistry education. The program provided a range of applications in several dental specialties and diverse clinical procedures. Highly targeted interventions significantly improved hand dexterity and increased self-assurance in only a few clinical sessions. The notable enhancements were the convergence of cavity walls, improvement of the pulpal floor, expansion of class I, refinement of the cavity shape, reduced pulpal exposure, and accelerated preparation. Students demonstrated superior performance in tasks involving 3D vision compared to tasks involving 2D vision. Furthermore, their performance was enhanced when provided with force feedback (FFB) compared to when it was not provided. Additionally, when students received input from both an instructor and a device, their performance was further

improved compared to receiving feedback from either the instructor or the device alone. The use of virtual reality, with or without guidance from an instructor, led to a gradual improvement in the precision and effectiveness of crown preparation and implant placement. Training in augmented reality (AR) for orthognathic surgery, virtual apicectomies, and the delivery of local anesthetic. The use of virtual reality has a limited impact on the acquisition of theoretical knowledge. The teacher's position and vocal instructions are crucial.

References

1. Perry S, Bridges SM, Burrow MF. A review of the use of simulation in dental education. Simul Healthc 2015; 10 (01) 31-37
2. Pottle J. Virtual reality and the transformation of medical education. Future Healthc J 2019; 6 (03) 181-185
3. Serrano CM, Wesselink PR, Vervoorn JM. First experiences with patient-centered training in virtual reality. J Dent Educ 2020; 84 (05) 607-614
4. Dixon J, Towers A, Martin N, Field J. Re-defining the virtual reality dental simulator: demonstrating concurrent validity of clinically relevant assessment and feedback. Eur J Dent Educ 2021; 25 (01) 108-116
5. Khurshid Z, Asiri FYI, Al Wadaani H. Human saliva: non-invasive fluid for detecting novel coronavirus (2019-nCoV).. Int J Environ Res Public Health 2020; 17 (07) 17-20
6. Towers A, Field J, Stokes C, Maddock S, Martin N. A scoping review of the use and application of virtual reality in pre-clinical dental education. Br Dent J 2019; 226 (05) 358-366
7. Dutã M, Amariei CI, Bogdan CM, Popovici DM, Ionescu N, Nuca CI. An overview of virtual and augmented reality in dental education. Oral Heal Dent Manag 2011; 10 (01) 42-49
8. Wu HK, Lee SW, Chang H, Liang JC. Current status, opportunities and challenges of augmented reality in education. Comput Educ 2013; 62: 41-49
9. Farronato M, Maspero C, Lanteri V. et al. Current state of the art in the use of augmented reality in dentistry: a systematic review of the literature. BMC Oral Health 2019; 19 (01) 135
10. Yoshida Y, Yamaguchi S, Kawamoto Y, Noborio H, Murakami S, Sohmura T. Development of a multi-layered virtual tooth model for the haptic dental training system. Dent Mater J 2011; 30 (01) 1-6
11. de IR Boer, Wesselink PR, Vervoorn JM. The creation of virtual teeth with and without tooth pathology for a virtual learning environment in dental education. Eur J Dent Educ 2013; 17 (04) 191-197
12. Al-Saud LM, Mushtaq F, Allsop MJ. et al. Feedback and motor skill acquisition using a haptic dental simulator. Eur J Dent Educ 2017; 21 (04) 240-247

13. Llena C, Folguera S, Forner L, Rodríguez-Lozano FJ. Implementation of augmented reality in operative dentistry learning. Eur J Dent Educ 2018; 22 (01) e122-e130
14. Suebnukarn S, Rhienmora P, Haddawy P. The use of cone-beam computed tomography and virtual reality simulation for pre-surgical practice in endodontic microsurgery. Int Endod J 2012; 45 (07) 627-632
15. Pohlenz P, Gröbe A, Petersik A. et al. Virtual dental surgery as a new educational tool in dental school. J Craniomaxillofac Surg 2010; 38 (08) 560-564
16. Huang T-K, Yang C-H, Hsieh Y-H, Wang J-C, Hung C-C. Augmented reality (AR) and virtual reality (VR) applied in dentistry. Kaohsiung J Med Sci 2018; 34 (04) 243-248
17. Kwon H-B, Park Y-S, Han J-S. Augmented reality in dentistry: a current perspective. Acta Odontol Scand 2018; 76 (07) 497-503
18. Ayoub A, Pulijala Y. The application of virtual reality and augmented reality in Oral & Maxillofacial Surgery. BMC Oral Health 2019; 19 (01) 238
19. Iwanaga J, Kamura Y, Nishimura Y. et al. A new option for education during surgical procedures and related clinical anatomy in a virtual reality workspace. Clin Anat 2021; 34 (03) 496-503
20. Liberati A, Altman DG, Tetzlaff J. et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. BMJ 2009; 339: b2700
21. Higgins JPT, Thomas J, Chandler J, et al, eds. Cochrane Handbook for Systematic Reviews of Interventions version 6.1 (updated September 2020). Cochrane; 2020. Available at: www.training.cochrane.org/handbook. Accessed October 12, 2020
22. Urbankova A, Engebretson SP. The use of haptics to predict preclinic operative dentistry performance and perceptual ability. J Dent Educ 2011; 75 (12) 1548-1557
23. de Boer IR, Lagerweij MD, de Vries MW, Wesselink PR, Vervoorn JM. The effect of force feedback in a virtual learning environment on the performance and satisfaction of dental students. Simul Healthc 2017; 12 (02) 83-90
24. Ria S, Cox MJ, Quinn BF, San Diego JP, Bakir A, Woolford MJ. A scoring system for assessing learning progression of dental students' clinical skills using haptic virtual workstations. J Dent Educ 2018; 82 (03) 277-285
25. Dwisaptarini AP, Suebnukarn S, Rhienmora P, Haddawy P, Koontongkaew S. Effectiveness of the multilayered caries model and visuo-tactile virtual reality simulator for minimally invasive caries removal: a randomized controlled trial. Oper Dent 2018; 43 (03) E110-E118
26. Mirghani I, Mushtaq F, Allsop MJ. et al. Capturing differences in dental training using a virtual reality simulator. Eur J Dent Educ 2018; 22 (01) 67-71