Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 7, 1452-1461
2025
Publisher: Learning Gate
DOI: 10.55214/25768484.v9i7.8937

The metaverse: A new frontier for dental education

Nada Hashim[1*], Rasha Babiker[2], Vivek Padmanabhan[3], Riham Mohamed[4], Ayman Ahmed[5], Muhammed Mustahsen Rahman[6]
[1,2,3,4,6]RAK College of Dental Sciences, RAK Medical & Health Sciences University, Ras al-Khaimah, UAE; nada.tawfig@rakmhsu.ac.ae (N.H.).
[5]Faculty of Dentistry, Nile University, Khartoum, Sudan.

Abstract: Integrating the metaverse into dentistry education offers a significant opportunity to transform how dental students learn and interact with their educational environment. The metaverse is a digital space that combines augmented reality (AR), virtual reality (VR), and blockchain technologies to provide an immersive and participatory experience. This review assesses the potential benefits and applications of the metaverse in dental education and discusses the challenges and considerations for its effective implementation. Additionally, it highlights the importance of a comprehensive and coordinated strategy, which involves collaboration among educators, technologists, and regulatory bodies, to establish a solid foundation for the use of the metaverse in dental education.

Keywords: *Augmented reality (Ar), Clinical simulation, Dental education, Immersive learning, Metaverse, Virtual reality (VR).*

1. Introduction

Rapid technological advancements have transformed numerous industries, and dental education is no exception. The emergence of the metaverse, a convergence of virtual, augmented, and physical realities, could revolutionize how dental students learn and interact with their educational environment. The Metaverse can be described as a digital universe that combines augmented reality (AR), virtual reality (VR), and blockchain technology to create an interactive and immersive environment. It allows users to interact with each other and digital objects in real-time, providing a sense of presence and engagement [1]. The metaverse can be conceptualized as a 3D digital space that blends the real and virtual worlds. It allows users to engage in a variety of activities through avatars and interact with other players and virtual objects [2, 3].

In the realm of dental education, the metaverse presents a transformative opportunity to enhance learning experiences, improve access and inclusivity, and foster global collaboration [4]. This virtual environment offers dental students a unique opportunity to immerse themselves in simulated clinical scenarios, practicing procedures and techniques without the physical world's limitations. This review aims to explore the potential benefits and applications of the metaverse in dental education and to identify the challenges and considerations for its successful implementation [5].

2. Metaverse in Dental Education

Traditional dental education is often based on practical training, anatomical models, and actual clinical practice. Although these strategies are successful, they are typically limited by limited resources, accessibility challenges, and inconsistent availability for complicated situations [6].
Incorporating the metaverse into dental education tackles these obstacles by offering a

History: Received: 21 May 2025; Revised: 17 June 2025; Accepted: 20 June 2025; Published: 18 July 2025
* Correspondence: nada.tawfig@rakmhsu.ac.ae

comprehensive, interactive, and adaptable solution that surpasses geographical and physical limitations. This innovative approach not only trains students for the requirements of their profession but also provides them with the skills necessary to excel in a technologically sophisticated healthcare environment [4].

Within the realm of dental education, the Metaverse provides a platform that enables students and professionals to participate in lifelike simulations, virtual classrooms, and cooperative projects, beyond the constraints imposed by physical barriers. The metaverse has the potential to have a wide-ranging influence on dentistry education [7]. DentaLAV is a virtual platform that allows dental students to organize collaborative learning groups and practice real-world dental cases in a secure and controlled environment. This platform has been suggested to enhance interdisciplinary training in dentistry [8, 9].

Moreover, the use of artificial intelligence (AI) in dental education has seen substantial expansion in the last twenty years, offering the possibility to improve both the clinical and pedagogical elements of the discipline [10].

3. Advantages of Metaverse in Dental Education

Integrating the metaverse into dental education provides several benefits that significantly improve the learning process [4].

Dental students can participate in lifelike, practical training and interactive simulations through virtual reality (VR), augmented reality (AR), and other immersive technologies, creating a safe environment to perfect intricate procedures [11].

The metaverse facilitates worldwide cooperation, uniting students and professionals from many locations to engage in real-time contact and sharing of information. Additionally, it enhances accessibility and inclusiveness by enabling students in rural or underprivileged regions to get high-quality education. In addition, the metaverse facilitates ongoing professional growth by offering virtual conferences, seminars, and cutting-edge research prospects, thus enhancing the dynamism and efficacy of dental education [7].

3.1. Enhancing Clinical Simulation and Training

A crucial advantage of the metaverse in dental education is its capacity to provide students with authentic clinical simulations and practical instruction [11]. Dental students can engage in simulated treatments, communicate with virtual patients, and use digital instruments inside a secure and regulated setting, avoiding the potential hazards inherent in clinical situations [11].

Individualized student requirements may be accommodated via customization of this simulation-based training, allowing students to go at their preferred speed and practice processes until they have mastered the necessary skills. Furthermore, using artificial intelligence might augment the authenticity and customization of these virtual encounters, offering students essential evaluation and appraisal [12]. The DentaLAV platform offers a virtual learning platform that enables dental students to engage in collaborative learning groups and practice real-world dentistry cases in a simulated environment [8]. Students can run virtual dentistry clinics, overseeing patient flow management, treatment plans, and administrative activities. This extensive training guarantees they are well-equipped for every element of dental practice [13].

3.2. Expanding Access and Reducing Costs

The metaverse has the potential to enhance the accessibility of dental education and reduce associated costs. By eliminating the need for physical resources and infrastructure, there would be convenient access to a wide range of educational information and resources, which would help reduce the cost burden on institutions and students [14].

During the COVID-19 pandemic, the importance of remote learning and simulation-based training in dental education was particularly highlighted. By integrating virtual and augmented

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 7: 1452-1461, 2025
DOI: 10.55214/25768484.v9i7.8937

reality technology into the metaverse, dental students may receive continuous education and clinical training, even in situations where physical distance requirements or limited options for in-person instruction exist [15, 16].

In places affected by conflict, the metaverse presents significant benefits for dental students by offering a safe and consistent teaching environment, even in the midst of continuing violence [17].

Virtual classrooms and simulations facilitate continuous education by allowing students to engage in dental treatments and lectures from a distant location, removing the need for physical presence and the accompanying risks [18]. Their educational experience is enriched via international collaboration and guidance from foreign instructors, compensating for restricted access to local resources. The metaverse enhances mental well-being by fostering a sense of inclusion and providing psychological solace from the harsh realities of battle [19]. Additionally, it offers flexible and variable learning opportunities, ensuring the protection of educational infrastructure and data security, which is crucial in places impacted by violence. This innovative method guarantees the continuous transmission of knowledge and enhances the well-being and prospects of dentistry students in conflict-affected areas [20].

3.3. Virtual Consultation

Virtual consultations or Tele-dentistry can be conducted within the metaverse, providing students with exposure to remote diagnosis and treatment planning. This exposure is valuable as tele-dentistry becomes increasingly important in modern dental practice [21].

3.4. Fostering Collaboration and Interdisciplinary Learning

The metaverse has the potential to facilitate collaborative and multidisciplinary learning in dental education in addition to simulation-based instruction. By creating virtual learning environments that facilitate collaboration, information exchange, and the resolution of complex problems, the metaverse can enhance the critical thinking, communication, and cooperation skills essential for dental success [22]. Furthermore, the metaverse enables dental students to engage with specialists from other healthcare disciplines, including medicine, nursing, and pharmacy, fostering a more comprehensive and integrated approach to patient care: Professional Development and Continuing Education.

Dental professionals can participate in workshops and seminars, attend virtual conferences, and engage in continuing education sessions in the metaverse to remain informed about the most recent developments in the field [23, 24].

This ongoing learning is contingent upon maintaining high standards of care. In the metaverse, institutions can also provide certifications and courses, simplifying the process of professionals obtaining additional qualifications without traveling [22].

3.5. Research and Innovation

Virtual environments enable gathering extensive data on student performance and learning outcomes, aiding instructors in enhancing and optimizing teaching approaches and employing a data-driven strategy, resulting in more efficient teaching techniques. The metaverse may function as a central location for conducting research and fostering innovation, allowing for the controlled testing and evaluation of novel methodologies, materials, and technologies inside a virtual environment. This promotes ongoing improvement in dental education and practice [25].

3.6. Accessibility and Inclusivity

The metaverse has the potential to enhance the accessibility of dental education for students residing in rural or underserved regions, providing them access to materials and opportunities that would not be locally accessible. The process of democratizing education guarantees equal chances for every individual. Virtual environments may be tailored to fit various learning styles and demands,

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 7: 1452-1461, 2025
DOI: 10.55214/25768484.v9i7.8937

enhancing inclusivity in dentistry education. This inclusion guarantees that any student, regardless of background or ability, may benefit from top-notch education [4, 7].

4. Implementation of a Metaverse in Different Dental Specialty

The metaverse has the potential to revolutionize various dental specialties by providing immersive, interactive, and innovative learning and practice environments. In general dentistry, the metaverse can facilitate virtual patient consultations and diagnosis, simulation of common dental procedures, and the use of interactive patient education tools [26]. For orthodontics, it enables 3D visualization of dental and skeletal structures, simulation of orthodontic appliance placement, and virtual treatment planning and progress tracking [27]. In the field of oral and maxillofacial surgery, the metaverse allows for the simulation of complex surgical procedures, 3D anatomy exploration, virtual dissection, and pre-operative planning and practice [28]. Periodontics benefits from the simulation of periodontal surgeries and treatments, virtual patient case studies, and interactive periodontal disease management [29, 30]. For endodontics, the metaverse offers the simulation of root canal treatments, 3D visualization of tooth anatomy, and virtual practice of endodontic techniques [31]. Prosthodontics can utilize the metaverse for the virtual design and simulation of dental prosthetics, interactive denture and implant planning, and 3D printing simulations for prosthetic devices [32, 33]. Pediatric dentistry can leverage it for the simulation of child-specific dental procedures, virtual behavior management training, and interactive educational games for children [34]. Public health dentistry can implement virtual health education campaigns, simulation of community dental programs, and training for disaster and crisis management [35]. Oral pathology benefits from 3D visualization of oral diseases, virtual biopsy and diagnostic simulations, and interactive case studies for rare conditions. Finally, dental radiology can utilize the metaverse for the simulation of radiographic techniques, 3D interpretation of radiographs, and interactive learning of radiographic anatomy [36, 37]. By integrating these applications into their respective specialties, the metaverse can significantly enhance dental education, training, and practice, leading to improved patient care and outcomes.

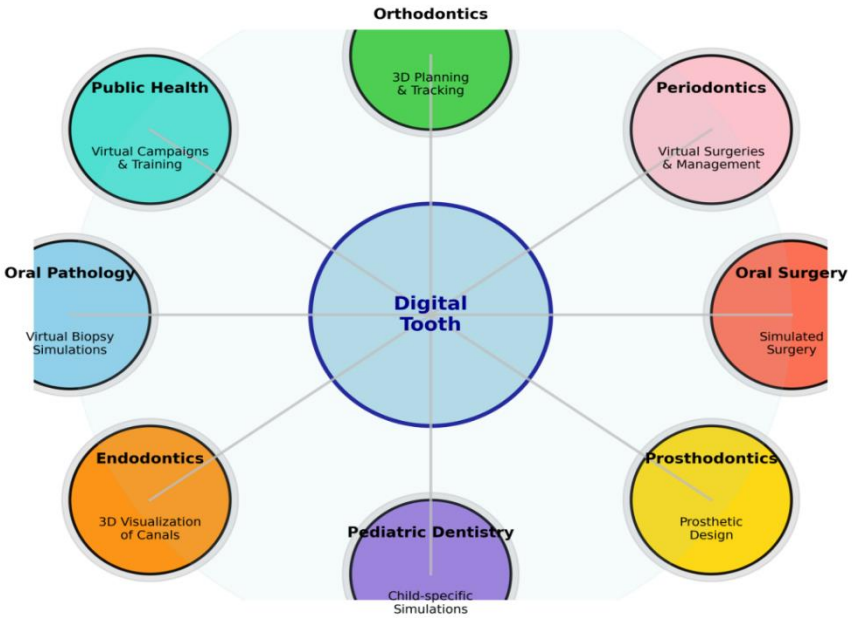

Figure 1.
Highlights the integration of the Metaverse in dental education and practice, centered around the "Digital Tooth."

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 7: 1452-1461, 2025
DOI: 10.55214/25768484.v9i7.8937

Each specialty benefits uniquely: Orthodontics uses 3-D visualization and virtual treatment planning, while Periodontics enables virtual surgeries and case management. Oral Surgery supports simulated complex procedures, and Prosthodontics focuses on virtual prosthetic design and 3D printing. Pediatric Dentistry incorporates child-specific simulations and behavioral training, while Public Health Dentistry leverages virtual campaigns and disaster management. The connecting lines represent collaboration and shared technological advancements across all specialties through the unified Metaverse platform.

5. Comparing Metaverses and Conventional Methods in Dentistry

Metaverses in dentistry offer virtual simulations for training, remote access to education, and 3D models for patient consultations, making treatment planning precise with digital twins and AI assistance [10]. They engage patients through gamified education and virtual follow-ups while potentially reducing costs by minimizing the need for physical infrastructure [7]. Accessibility improves globally, especially for remote areas, though the high initial investment and steep learning curve are challenges [14]. Enhanced data management and advanced procedure simulations reduce errors and improve adaptability [19]. In contrast, conventional methods rely on hands-on practice, in-person consultations, and manual planning, which are familiar but limited by geographical constraints and higher costs, with a higher risk of human error and slower adoption of new practices [38].

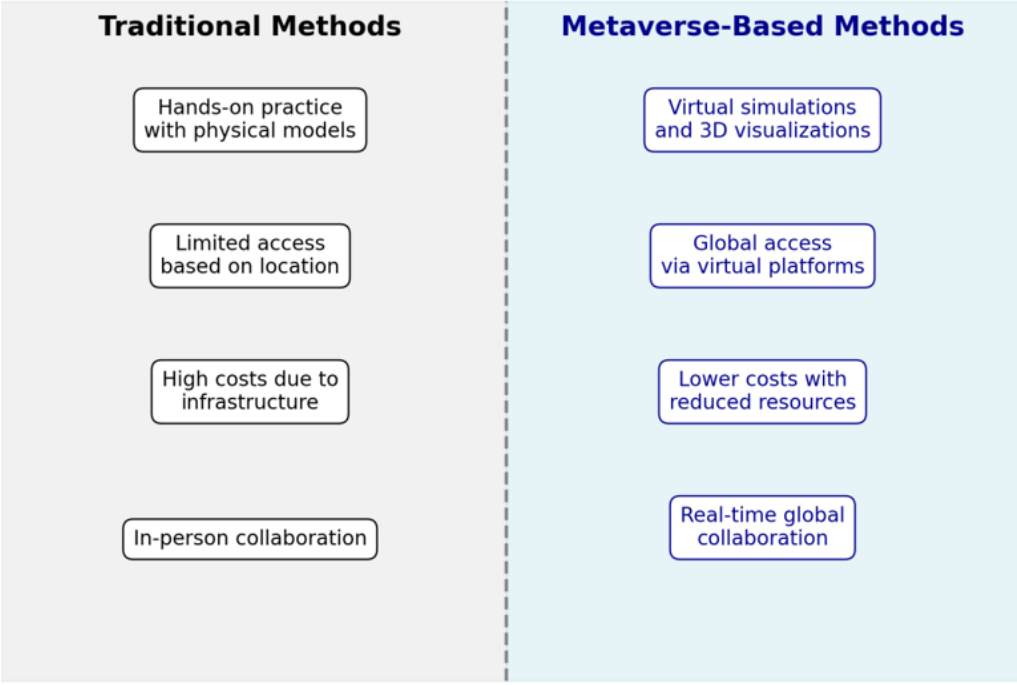

Figure 2.
Compares traditional and Metaverse-based dental education methods.

Traditional approaches rely on hands-on practice with physical models, limited access based on geographic location, high infrastructure costs, and in-person collaboration. In contrast, Metaverse-based methods offer virtual simulations and 3D visualizations, enabling immersive and realistic training experiences. They provide global access via virtual platforms, reduce costs by minimizing physical resource dependence, and facilitate real-time global collaboration among students and professionals. The dashed line in the middle highlights the transition from conventional to

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 7: 1452-1461, 2025
DOI: 10.55214/25768484.v9i7.8937

innovative educational practices enabled by the Metaverse.

6. Challenges and Considerations

While the benefits of incorporating the metaverse into dental education are significant and revolutionary, many issues and considerations need to be resolved before its successful implementation. These issues transcend technical, economic, and ethical limits, and it is crucial to tackle them for the metaverse to fully realize its promise in enhancing dental education. A comprehensive approach is necessary to provide equitable technological access and maintain virtual programs' excellence while tackling economic concerns and safeguarding privacy. Educational institutions might take proactive measures to overcome these challenges and establish a strong and prosperous basis for incorporating the metaverse into dentistry education.

A paramount concern is the potential for a decline in physical interaction and its impact on developing interpersonal communication skills, which are crucial in dentistry [10, 39]. Moreover, it is essential to comprehensively investigate artificial intelligence's ethical and legal implications in dentistry education. The document "Impact of Artificial Intelligence on Dental Education: A Review and Guide for Curriculum Update" states that more consensus is needed to safely and appropriately apply new technologies [10].

To address these issues, dental education institutions should implement a comprehensive approach that carefully considers the metaverse's benefits in relation to the importance of ongoing practical clinical training and the cultivation of interpersonal abilities. The future of the metaverse in dentistry education will depend heavily on the collaboration of educators, technologists, and regulatory bodies.

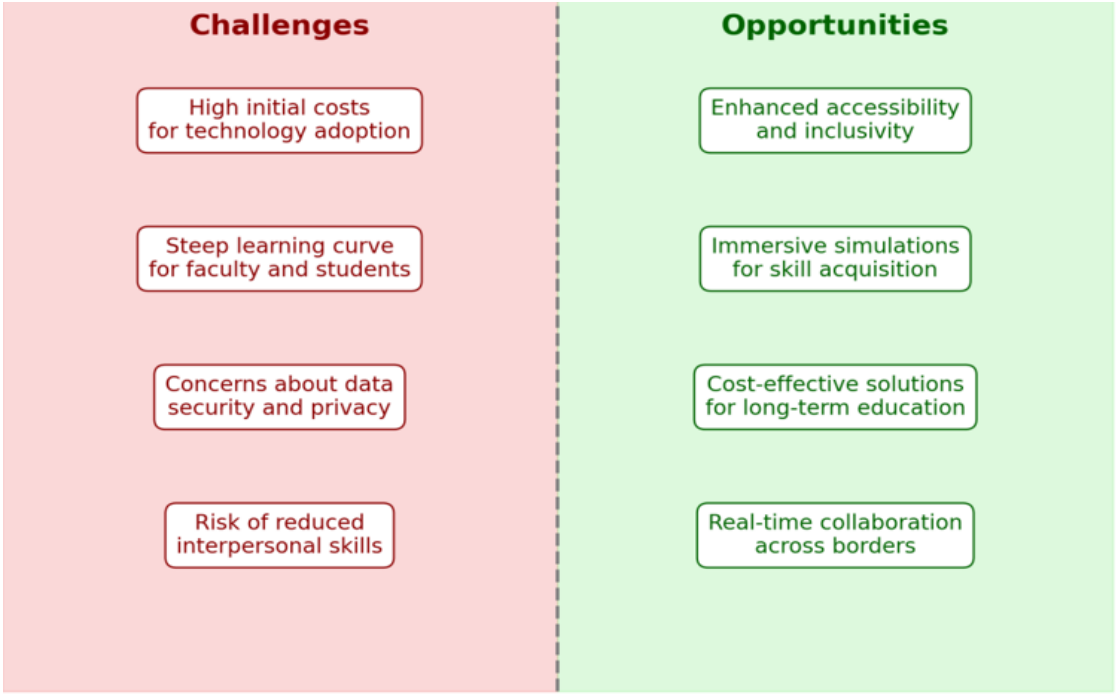

Figure 3.
Highlights the key challenges and opportunities associated with implementing the Metaverse in dental education.

On the left, challenges include high initial costs for adopting advanced technology, a steep learning curve for both faculty and students, concerns about data security and privacy, and the potential reduction of interpersonal skill development. On the right, opportunities showcase

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 7: 1452-1461, 2025
DOI: 10.55214/25768484.v9i7.8937

enhanced accessibility and inclusivity for global learners, immersive simulations that improve skill acquisition, cost-effective solutions for long-term education, and the ability to collaborate in real-time across borders. The contrasting layout emphasizes the balance between overcoming obstacles and leveraging innovative benefits.

7. Conclusion

The metaverse presents both opportunities and challenges for dental education. By embracing the potential of virtual and augmented reality, dental education can enhance student engagement, improve learning outcomes, and better prepare future dental professionals for the demands of the modern healthcare landscape. As the metaverse evolves, dental educators and institutions must remain adaptable and innovative, leveraging this transformative technology to deliver a comprehensive and enriching educational experience.

8. Future Research

Future research on using the metaverse in dentistry education should focus on key areas to fully understand and harness its capabilities. Studying the efficacy of learning outcomes is a crucial topic for future research.

A comparative study is essential for evaluating the effectiveness of traditional dental education methods compared to metaverse-based approaches regarding skill acquisition, knowledge retention, and clinical competence demonstration. Longitudinal studies are necessary to assess students' performance in actual clinical environments and track the educational progress of students in the metaverse in comparison to those taught using traditional methods over a period of time.

Research on technology integration is quite significant. An analysis of artificial intelligence's influence on enhancing personalized learning experiences and providing instant feedback might have a substantial positive effect on student learning. Developing standardized protocols to ensure interoperability across various metaverse platforms and educational tools is essential for seamless integration and improved user satisfaction.

Future research needs to prioritize accessibility and diversity as essential elements. It is crucial to have strategies that ensure all students, regardless of where they live or their socioeconomic status, have equitable access to necessary technology and resources. This is necessary for their involvement in education that takes place in a virtual reality environment. Additional studies should explore how virtual environments might be customized to accommodate the various learning needs and disabilities of people, hence improving inclusion in dentistry education. Studying the cost-effectiveness of metaverse technologies in dental education is an essential area of research. Conducting cost-benefit analyses may provide valuable information about the financial implications of implementing these technologies, such as initial costs, continuous upkeep, and potential savings from less dependence on physical resources. Moreover, it is essential to research sustainable funding ways to provide financial backing for integrating metaverse technology in educational institutions.

Subsequent studies should prioritize the exploration of mental health and well-being. It is crucial to investigate the impact of immersive virtual worlds on the mental health and well-being of students, particularly in high-stress educational environments. Examining the potential of the metaverse to foster a sense of community and provide support to students is of the utmost importance. This exploration aims to reduce feelings of isolation and improve mental well-being.

It is crucial to address ethical and legal issues to ensure the successful incorporation of the metaverse in dental education. Researching the most efficient strategies for safeguarding student and patient data in virtual environments and ensuring compliance with privacy laws and regulations is paramount. It is crucial to analyze the ethical implications of using artificial intelligence in dental education, including questions of bias, accountability, and transparency. Exploring curriculum development in more depth is essential for future research. Developing and evaluating innovative curricula that use metaverse technology is crucial as long as they comply with educational standards

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 7: 1452-1461, 2025
DOI: 10.55214/25768484.v9i7.8937

and accomplish learning objectives. Moreover, researching effective tactics for training faculty members in using metaverse technologies and integrating them into their teaching methods is crucial to guarantee a successful implementation.

Future research should prioritize collaboration across different disciplines. Exploring the metaverse's ability to facilitate interprofessional education and allowing dental students to collaborate with colleagues from other healthcare disciplines has the potential to enhance the overall learning experience. Encouraging collaborative research initiatives among dental schools, technology firms, and healthcare institutions may foster innovation and enable the sharing of knowledge.

Future research has the potential to make significant contributions to developing a comprehensive, practical, and all-encompassing educational framework utilizing the metaverse. This may be achieved by prioritizing five crucial areas. This initiative will enhance the quality of dentistry education and better prepare aspiring dental professionals to tackle the demands of a rapidly evolving healthcare landscape.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

Copyright:

References

[1] S. Kaddoura and F. Al Husseiny, "The rising trend of Metaverse in education: Challenges, opportunities, and ethical considerations," *PeerJ Computer Science*, vol. 9, p. e1252, 2023. https://doi.org/10.7717/peerj-cs.1252

[2] M. Z. Iqbal and A. G. Campbell, "Metaverse as tech for good: Current progress and emerging opportunities," *Virtual Worlds*, vol. 2, no. 4, pp. 326–342, 2023. https://doi.org/10.3390/virtualworlds2040019

[3] A. Dawood, B. M. Marti, V. Sauret-Jackson, and A. Darwood, "3D printing in dentistry," *British Dental Journal*, vol. 219, no. 11, pp. 521-529, 2015.

[4] L. Locurcio, "Dental education in the metaverse," *British Dental Journal*, vol. 232, no. 4, pp. 191-191, 2022.

[5] H. Koolivand *et al.*, "Comparison of the effectiveness of virtual reality-based education and conventional teaching methods in dental education: A systematic review," *BMC Medical Education*, vol. 24, no. 1, pp. 1-8, 2024.

[6] A. I. Spielman, "Dental education and practice: Past, present, and future trends," *Frontiers in Oral Health*, vol. 5, p. 1368121, 2024. https://doi.org/10.3389/froh.2024.1368121

[7] X. Zhang, Y. Chen, L. Hu, and Y. Wang, "The metaverse in education: Definition, framework, features, potential applications, challenges, and future research topics," *Frontiers in Psychology*, vol. 13, p. 1016300, 2022. https://doi.org/10.3389/fpsyg.2022.1016300

[8] W. D. Bravo-Torres, J. J. Alvarado-Cordero, C. M. Cevallos-Ludeña, P. E. Vintimilla-Tapia, J. F. Bravo-Torres, and P. L. Gallegos-Segovia, "DentaLAV: A virtual platform for dental multidisciplinary learning," presented at the 2017 IEEE Colombian Conference on Communications and Computing (COLCOM), IEEE, 2017.

[9] K. I. Afrashtehfar, J.-W. Yang, A. Al-Sammarraie, H. Chen, and M. H. Saeed, "Pre-clinical undergraduate students' perspectives on the adoption of virtual and augmented reality to their dental learning experience: A one-group pre- and post-test design protocol," *F1000Research*, vol. 10, p. 473, 2023.

[10] A. Thurzo, M. Strunga, R. Urban, J. Surovková, and K. I. Afrashtehfar, "Impact of artificial intelligence on dental education: A review and guide for curriculum update," *Education Sciences*, vol. 13, no. 2, p. 150, 2023. https://doi.org/10.3390/educsci13020150

[11] R. Moussa, A. Alghazaly, N. Althagafi, R. Eshky, and S. Borzangy, "Effectiveness of virtual reality and interactive simulators on dental education outcomes: systematic review," *European journal of dentistry*, vol. 16, no. 01, pp. 14-31, 2022.

[12] V. Willis, "The role of artificial intelligence (AI) in personalizing online learning," *Journal of Online and Distance Learning*, vol. 3, no. 1, pp. 1-13, 2024.

[13] M. Zallio and P. J. Clarkson, "Designing the metaverse: A study on inclusion, diversity, equity, accessibility and safety for digital immersive environments," *Telematics and Informatics*, vol. 75, p. 101909, 2022. https://doi.org/10.1016/j.tele.2022.101909

[14] I. Suh, T. McKinney, and K.-C. Siu, "Current perspective of metaverse application in medical education, research, and patient care," *Virtual Worlds*, vol. 2, no. 2, pp. 115–128, 2023.

[15] C. M. Toquero, "Challenges and opportunities for higher education amid the COVID-19 pandemic: The Philippine context," *Pedagogical Research*, vol. 5, no. 4, p. em0063, 2020.

[16] K. A. Gamage, D. I. Wijesuriya, S. Y. Ekanayake, A. E. Rennie, C. G. Lambert, and N. Gunawardhana, "Online delivery of teaching and laboratory practices: Continuity of university programmes during COVID-19 pandemic," *Education Sciences*, vol. 10, no. 10, p. 291, 2020. https://doi.org/10.3390/educsci10100291

[17] M. Tukur *et al.*, "The Metaverse digital environments: A scoping review of the techniques, technologies, and applications," *Journal of King Saud University-Computer and Information Sciences*, vol. 36, no. 2, p. 101967, 2024. https://doi.org/10.1016/j.jksuci.2024.101967

[18] Y. Li *et al.*, "The current situation and future prospects of simulators in dental education," *Journal of Medical Internet Research*, vol. 23, no. 4, p. e23635, 2021.

[19] X. Chen, D. Zou, H. Xie, and F. L. Wang, "Metaverse in education: Contributors, cooperations, and research themes," *IEEE Transactions on Learning Technologies*, vol. 16, no. 6, pp. 1111-1129, 2023.

[20] W. Villegas-Ch, J. García-Ortiz, and S. Sánchez-Viteri, "Educational advances in the metaverse: Boosting learning through virtual and augmented reality and artificial intelligence," *IEEE Access*, vol. 12, pp. 1-20, 2024.

[21] N. Dagli, "Advancement in telemedicine and teledentistry with virtual reality and metaverse," *Journal of International Oral Health*, vol. 14, no. 6, pp. 529-530, 2022.

[22] K. Farrukh, "Metaverse in medical education: A paradigm shift," *Pakistan Journal of Medical Sciences*, vol. 40, no. 1Part-I, p. 255, 2024.

[23] M. Lee, P. Liang, and Q. Yang, "CoAuthor: Designing a human-ai collaborative writing dataset for exploring language model capabilities," in *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems, New Orleans, LA, USA*, 2022, pp. 1–19.

[24] W. Zhang, B. Han, and P. Hui, "SSEAR: scaling experiences in multi-user augmented reality," in *Proceedings of IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, 2022.

[25] R. Verma, P. A. Petare, M. Shamim, T. Gupta, and G. Singh, "Exploring the impact of virtual learning environments on student engagement and academic achievement," *Journal of Survey in Fisheries Sciences*, vol. 10, no. 1S, pp. 5912-5923, 2023.

[26] K. Afrashtehfar, H. Eimar, R. Yassine, S. Abi-Nader, and F. Tamimi, "Evidence-based dentistry for planning restorative treatments: barriers and potential solutions," *European Journal of Dental Education*, vol. 21, no. 4, pp. e7-e18, 2017. https://doi.org/10.1111/eje.12208

[27] I. Christopoulou, E. G. Kaklamanos, M. A. Makrygiannakis, I. Bitsanis, P. Perlea, and A. I. Tsolakis, "Intraoral scanners in orthodontics: A critical review," *International Journal of Environmental Research and Public Health*, vol. 19, no. 3, p. 1407, 2022. https://doi.org/10.3390/ijerph19031407

[28] Y. Wang, C. Li, L. Qu, H. Cai, and Y. Ge, "Application and challenges of a metaverse in medicine," *Frontiers in Robotics and AI*, vol. 10, p. 1291199, 2023. https://doi.org/10.3389/frobt.2023.1291199

[29] S. Ramani, R. Vijayalakshmi, J. Mahendra, C. NalinaKumari, and N. Ravi, "Artificial intelligence in periodontics–An overview," *IP International Journal of Periodontology and Implantology*, vol. 8, no. 2, pp. 71-4, 2023.

[30] J. Korgaonkar, A. Y. Tarman, H. C. Koydemir, and S. S. Chukkapalli, "Periodontal disease and emerging point-of-care technologies for its diagnosis," *Lab on a Chip*, vol. 24, no. 14, pp. 3326-3346, 2024.

[31] S. Sabertahan, O. Peters, and M. Farajollahi, "Endodontics in the Metaverse: Exploring new Frontiers," *International Endodontic Journal*, vol. 57, pp. 123–130, 2024. https://doi.org/10.1111/iej.14063

[32] M. Hasanzade, M. Shirani, K. I. Afrashtehfar, P. Naseri, and M. Alikhasi, "In vivo and in vitro comparison of internal and marginal fit of digital and conventional impressions for full-coverage fixed restorations: A systematic review and meta-analysis," *Journal of Evidence Based Dental Practice*, vol. 19, no. 3, pp. 236-254, 2019. https://doi.org/10.1016/j.jebdp.2019.04.003

[33] K. I. Afrashtehfar, N. A. Alnakeb, and M. K. Assery, "Accuracy of intraoral scanners versus traditional impressions: A rapid umbrella review," *Journal of Evidence-Based Dental Practice*, vol. 22, no. 3, p. 101719, 2022. https://doi.org/10.1016/j.jebdp.2022.101719

[34] S. Duman, D. Çelik Özen, and Ş. Duman, "Metaverse in paediatric dentistry," *European Archives of Paediatric Dentistry*, vol. 23, no. 4, pp. 655-656, 2022. https://doi.org/10.1007/s40368-022-00733-7

[35] A. Albujeer and M. Khoshnevisan, "Metaverse and oral health promotion," *British Dental Journal*, vol. 232, no. 9, pp. 587-587, 2022. https://doi.org/10.1038/s41415-022-4255-1

[36] T. P. Silva, M. F. Andrade-Bortoletto, D. Q. Freitas, C. Oliveira-Santos, and W. M. Takeshita, "Metaverse and oral and maxillofacial radiology: Where do they meet?," *European Journal of Radiology*, vol. 170, p. 111210, 2024. https://doi.org/10.1016/j.ejrad.2023.111210

[37] O. Moztarzadeh *et al.*, "Metaverse and medical diagnosis: A blockchain-based digital twinning approach based on MobileNetV2 algorithm for cervical vertebral maturation," *Diagnostics*, vol. 13, no. 8, p. 1485, 2023. https://doi.org/10.3390/diagnostics13081485

[38] V. V. Gordan *et al.*, "Methods used by dental practice-based research network (DPBRN) dentists to diagnose dental caries," *Operative Dentistry*, vol. 36, no. 1, pp. 2-11, 2011. https://doi.org/10.2341/10-137-CR

[39] Y. Wang, L.-H. Lee, T. Braud, and P. Hui, "Re-shaping post-COVID-19 teaching and learning: A blueprint of virtual-physical blended classrooms in the metaverse era," in *2022 IEEE 42nd International Conference on Distributed Computing Systems Workshops, IEEE*, 2022, pp. 241-247.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 9, No. 7: 1452-1461, 2025
DOI: 10.55214/25768484.v9i7.8937