frontiers | Research Topics

Embedding current trends and innovative pedagogies in education in oral health: advancing educational practices and research

Edited by
Melanie Nasseripour, Ana Angelova Volponi, Jonathan San Diego, Angelo Leone and Bo Danielsen

Published in
Frontiers in Medicine
Frontiers in Oral Health

ISSN 1664-8714
ISBN 978-2-8325-6066-2
DOI 10.3389/978-2-8325-6066-2

About Frontiers

Frontiers is more than just an open access publisher of scholarly articles: it is a pioneering approach to the world of academia, radically improving the way scholarly research is managed. The grand vision of Frontiers is a world where all people have an equal opportunity to seek, share and generate knowledge. Frontiers provides immediate and permanent online open access to all its publications, but this alone is not enough to realize our grand goals.

Frontiers journal series

The Frontiers journal series is a multi-tier and interdisciplinary set of open-access, online journals, promising a paradigm shift from the current review, selection and dissemination processes in academic publishing. All Frontiers journals are driven by researchers for researchers; therefore, they constitute a service to the scholarly community. At the same time, the *Frontiers journal series* operates on a revolutionary invention, the tiered publishing system, initially addressing specific communities of scholars, and gradually climbing up to broader public understanding, thus serving the interests of the lay society, too.

Dedication to quality

Each Frontiers article is a landmark of the highest quality, thanks to genuinely collaborative interactions between authors and review editors, who include some of the world's best academicians. Research must be certified by peers before entering a stream of knowledge that may eventually reach the public - and shape society; therefore, Frontiers only applies the most rigorous and unbiased reviews. Frontiers revolutionizes research publishing by freely delivering the most outstanding research, evaluated with no bias from both the academic and social point of view. By applying the most advanced information technologies, Frontiers is catapulting scholarly publishing into a new generation.

What are Frontiers Research Topics?

Frontiers Research Topics are very popular trademarks of the *Frontiers journals series*: they are collections of at least ten articles, all centered on a particular subject. With their unique mix of varied contributions from Original Research to Review Articles, Frontiers Research Topics unify the most influential researchers, the latest key findings and historical advances in a hot research area.

Find out more on how to host your own Frontiers Research Topic or contribute to one as an author by contacting the Frontiers editorial office: frontiersin.org/about/contact

Embedding current trends and innovative pedagogies in education in oral health: advancing educational practices and research

Topic editors

Melanie Nasseripour — King's College London, United Kingdom
Ana Angelova Volponi — King's College London, United Kingdom
Jonathan San Diego — King's College London, United Kingdom
Angelo Leone — University of Palermo, Italy
Bo Danielsen — University of Copenhagen, Denmark

Citation

Nasseripour, M., Angelova Volponi, A., San Diego, J., Leone, A., Danielsen, B., eds. (2025). *Embedding current trends and innovative pedagogies in education in oral health: advancing educational practices and research*. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-8325-6066-2

Table of contents

frontiers | Frontiers in Oral Health

TYPE Editorial
PUBLISHED 19 February 2025
DOI 10.3389/froh.2025.1569865

OPEN ACCESS

EDITED AND REVIEWED BY
Fawad Javed,
University of Rochester Medical Center,
United States

*CORRESPONDENCE
Melanie Nasseripour
melanie.nasseripour@kcl.ac.uk

RECEIVED 02 February 2025
ACCEPTED 03 February 2025
PUBLISHED 19 February 2025

CITATION
Nasseripour M, Leone A, Angelova Volponi A, Danielsen B, San Diego J and Haddad AE (2025) Editorial: Embedding current trends and innovative pedagogies in education in oral health: advancing educational practices and research.
Front. Oral. Health 6:1569865.
doi: 10.3389/froh.2025.1569865

Editorial: Embedding current trends and innovative pedagogies in education in oral health: advancing educational practices and research

Melanie Nasseripour[1]*, Angelo Leone[2], Ana Angelova Volponi[3], Bo Danielsen[4], Jonathan San Diego[1] and Ana Estela Haddad[5]

[1]Centre for Dental Education, Faculty of Dentistry, Oral and Cranio-Facial Sciences, King's College London, London, United Kingdom, [2]School of Medicine and Surgery, University of Palermo, Palermo, Italy, [3]Centre for Craniofacial and Regenerative Biology, Faculty of Dentistry, Oral & Craniofacial Sciences, King's College London, London, United Kingdom, [4]School of Oral Health Care, University of Copenhagen, Copenhagen, Denmark, [5]Universidade de São Paulo, Sao Paulo, Brazil

KEYWORDS

education, innovation, oral health, pedagogy, technology

Editorial on the Research Topic
Embedding current trends and innovative pedagogies in education in oral health: advancing educational practices and research

Introduction

In the ever-evolving field of healthcare education, staying ahead of emerging trends and embracing innovative teaching methods is crucial for preparing the next generation of oral health professionals. As dentistry and oral health advance with technological breakthroughs and shifting patient needs, educators must continually refine their teaching strategies. This special issue explores these evolving educational approaches, showcasing their impact on both classroom instruction and oral health research.

Current trends in oral health education

Digital technology is transforming education across many fields, and oral health education is no exception. Innovations like telehealth, artificial intelligence (AI), and simulation-based learning are changing how students acquire knowledge and develop clinical skills.

Furthermore, there is a increasing emphasis on interdisciplinary collaboration and community-based learning. These approaches prepare students for the complexities of real-world healthcare by fostering teamwork with professionals from other fields and engagement with diverse communities.

By extending learning beyond traditional clinical settings, they gain a comprehensive perspective on patient care.

Innovative pedagogies in focus

Alongside technological advances, educators are also exploring new teaching methods that promote deeper understanding and critical thinking. One such approach, competency-based education (CBE), is gaining popularity in oral health programs. Unlike traditional models that emphasize time spent in the classroom, CBE focuses on mastering specific skills, ensuring that students are fully prepared to deliver high-quality care upon graduation.

Another promising strategy is the flipped classroom model, where students review course materials outside of class and use class time to practice skills and engage in more interactive learning activities. This approach creates a more collaborative environment and allows students to take a more active role in their learning.

The role of research in advancing education

Oral health education continues to evolve, and research is crucial in guiding these changes. Evaluating and refining teaching methods through education research ensures that innovations are effective in improving student learning and clinical outcomes. This special issue invites contributions that examine the impact of these new approaches on student success, their relevance to real-world practice, and the experiences of both educators and learners.

Integrating research into the curriculum is equally essential. Engaging in research helps students develop critical thinking skills and learn to apply evidence-based solutions to problems in oral health. By doing so, they not only enhance their educational experience but also contribute to the broader body of knowledge in the field immediately and throughout of their lifetime.

Special issue focus

The special issue highlights the following key points:

There is a critical need for e-learning platforms to address not only the academic requirements of students but also their psychological well-being (Zahid and Agou).

The virtual learning cannot fully replace the benefits of in-person instruction. Simulations and virtual patients can be used to establish clinical learning outcomes prior to the expected application of chairside learning (Meng).

Blended learning, which combines in-person and online learning offers students greater flexibility in accessing and engaging with learning materials, allowing them to learn at their own pace. There is a need to develop a more engaging and interactive online learning environment that rationally blends both online and face-to-face instructions, incorporating elements like group discussions, peer interactions, and virtual patient cases can help capture the collaborative nature of traditional in-person learning (Nasseripour et al.).

Both students and educators require support in developing essential, transferrable skills, including time management, proficiency in using AI tools for education, and general computing skills among many other skills. Strengthening these skills will enhance their ability to adapt to evolving learning and teaching methods (Byrne and Glasser).

For educators, digital and pedagogical literacy, particularly the ability to embed technology into teaching practice, remains essential. Even with a return to on-campus learning, maintaining a balance of synchronous, asynchronous, online, and in-person instruction offers valuable benefits. Developing these skills ensures educators can effectively navigate and enhance this blended approach to teaching.

Curriculum and pedagogy must continuously evolve to adapt and keep pace with advancements in:

- Knowledge
- Technology
- Understanding of how students learn, and the evolving role of oral health graduates
- The diverse needs of the communities they serve
- Interprofessional collaborative practice

Innovative teaching methods not only enhance student learning but also foster teamwork among students and educators, improve feedback quality and mechanisms, reduce costs and promote culture of continuous learning. Additionally, they can help alleviate the stress that oral health students face as they prepare to enter the job market, a significant concern for many (Babadi et al., Miao et al.).

Dialogue with students and staff to explain the reasoning behind any new pedagogy, new technology adoption is essential to the success of such endeavours (Hasan and Jones).

When innovations are introduced, a review of previous approaches is required to determine what can be modified (reduced or removed), helping to maintain a manageable workload for both students and educators. Thoughtful planning of this transition by phasing in new approaches and phasing out the outdated ones, is crucial to sustaining goodwill in adopting innovation.

For innovations to be successful, educational institutions must be willing to rethink teaching and assessment approaches, effectively manage the innovative changes, and provide the necessary physical and technological resources (Liu et al.).

Time or lack thereof is repeatedly reported as a barrier to implementing innovative pedagogies. Institutions must value the time it takes to develop and implement innovative approaches to oral health education (Nasseripour et al.).

Conclusion and next steps

As oral health education continues to evolve, integrating emerging trends and innovative teaching methods in the curricula is essential. The contributions in this special issue offer valuable insights for educators, researchers, and practitioners who are working to transform educational practices. By fostering a collaborative environment that prioritizes both learning and research, we can ensure that future oral health professionals are well-equipped to meet the needs of an ever-changing healthcare landscape.

We encourage readers to explore the articles in this issue, reflect on how they might apply these ideas in their own teaching, and consider how collaboration across disciplines can further enhance the learning experience. Together, we can shape the future of oral health education and prepare the next generation of practitioners for success.

Author contributions

MN: Writing – original draft, Writing – review & editing. AL: Writing – original draft, Writing – review & editing. AA: Writing – original draft, Writing – review & editing. BD: Writing – original draft, Writing – review & editing. JS: Writing – original draft, Writing – review & editing. AH: Writing – original draft, Writing – review & editing.

Publisher's note

frontiers | Frontiers in Oral Health

TYPE Perspective
PUBLISHED 03 November 2023
DOI 10.3389/froh.2023.1233983

OPEN ACCESS

EDITED BY
Angelo Leone,
University of Palermo, Italy

REVIEWED BY
Michael Wolcott,
High Point University, United States

*CORRESPONDENCE
Samantha J. Byrne
✉ sbyrne@unimelb.edu.au

†These authors have contributed equally to this work and share first authorship

RECEIVED 03 June 2023
ACCEPTED 19 October 2023
PUBLISHED 03 November 2023

CITATION
Byrne SJ and Glasser S (2023) Creativity as a framework for innovation in dental education. Front. Oral. Health 4:1233983. doi: 10.3389/froh.2023.1233983

Creativity as a framework for innovation in dental education

Samantha J. Byrne[1*†] and Solange Glasser[2†]

[1]Melbourne Dental School, University of Melbourne, Melbourne, VIC, Australia,
[2]Melbourne Conservatorium of Music, University of Melbourne, Melbourne, VIC, Australia

Dental education is rich with examples of innovation as educators have responded to advances in knowledge, technology, the needs of the community, and most recently the challenges of the COVID-19 pandemic. Current challenges requiring innovative pedagogies include developing graduates who are interprofessional collaborative practice-ready, adapting to technological advances, embedding sustainability in the curriculum, and addressing equity and diversity in dental education. Creativity is the production of something that is novel and useful and is intimately linked to innovation which is the implementation of new and improved ways of doing things. To develop innovative pedagogies and address the current challenges facing dental education, educators and dental schools must reflect on the factors necessary for supporting creativity and innovation and seek to remove barriers to or biases against creativity. Here, we discuss the importance of creativity in supporting innovation in dental education, and call for leadership to actively support all elements of creativity for continued innovation to address the challenges we face in educating the future oral health workforce.

KEYWORDS

creativity, innovation, dental education, online learning, dental schools

1. Introduction

Both the practice of dentistry and dental education are rich with innovation. From tooth worms to the ecological plaque hypothesis, from amalgam to adhesive restorative materials, from traditional lectures to problem-based learning and from blackboards and chalk to 3D virtual models: curriculum and pedagogy must constantly adapt to advances in dental knowledge, in technology, in our understanding of how students learn, and the changing oral health needs of the community. Dental educators currently face multiple challenges necessitating innovative solutions. Addressing the global neglect of oral heath requires different models of care, with graduates able to engage in interprofessional collaborative practice and adapt to the diverse needs of the communities in which they will work (1). Graduates must be adaptable to technological advances during their practicing careers such as digital workflows and the impact of learning health systems on dental practice (2, 3). Environmental sustainability must be embedded into dental curriculum to reduce the impact of oral healthcare on the environment (4, 5). And more inclusive, humanistic learning environments are needed to combat equity and diversity in dental education (6).

In this article, we discuss the importance of supporting creativity to continue innovation in dental education. We start by defining creativity and innovation and examine a model of creativity. We then propose creativity as a framework to support innovation. We discuss elements required by individuals and organisations to nurture creativity and innovation, providing examples of these elements from dental education. We consider how these elements relate to a model of creativity and issue a call for action by leadership in dental

education to foster these elements in their staff and in their environments, in order to support continued innovation.

2. Discussion

2.1. Creativity and innovation

Creativity is highly appreciated within organisations, educational settings, and scientific endeavours (7, 8), and is strongly linked to innovation. Creativity is generally viewed as idea generation, and innovation as idea implementation, unsurprisingly leading to a focus on the impact of innovation and creativity as determinants of organisational performance and success (7). Indeed, Anderson and colleagues (2014) proposed the following integrative definition of creativity and innovation:

> Creativity and innovation at work are the process, outcomes, and products of attempts to develop and introduce new and improved ways of doing things. The creativity stage of this process refers to idea generation, and innovation refers to the subsequent stage of implementing ideas toward better procedures, practices, or products. Creativity and innovation can occur at the level of the individual, work team, organization, or at more than one of these levels combined but will invariably result in identifiable benefits at one or more of these levels of analysis (7) (p. 1298).

While creativity and innovation are suggested to occur at all levels or combinations of levels of an organisation, creativity has been argued to be primarily an individual process, whereas innovation represents group or social processes (9). Regardless of the potential weight of individual vs. group input into these processes, creativity and innovation remain complex phenomena that require leadership dedicated to fostering and maximising their benefits to ensure improved ways of working (7). Before we discuss how educational institutions can foster creativity and innovation, we will explore definitions and models of creativity, and what these might mean in the context of dental education.

2.2. Defining creativity

Creativity can be defined as the production of ideas that are both novel and useful. While this definition speaks to the essence of what creativity is often framed as, it may lack nuance when considering the role of educational systems in fostering creativity. The American Psychological Association (APA) considers creativity to be "The ability to produce or develop original work, theories, techniques, or thoughts. A creative individual typically displays originality, imagination, and expressiveness." (American Psychological Association, 2018) (10). The APA emphasises what the creative individual would typically display as a result of creative ideation. Perhaps more telling is the assertion that creativity is "The production of ideas and objects that are both novel or original and worthwhile or appropriate, that is, useful, attractive, meaningful, or correct. According to some researchers, in order to qualify as creative, a process of production must in addition be heuristic or open-ended rather than algorithmic (having a definite path to a unique solution) (11)." In this definition, from the Oxford Dictionary of Psychology, we see an amalgamation of two creative elements: the process of production (including the suggestion that this process be open-ended), and the product itself (in this case noted as being either an idea or object). However, there is no mention of the creative person themselves. Evidently, creativity is hard to pin down. We know what it is when we see it, or when we experience it ourselves, but positioning it or even quantifying it is difficult.

Beyond the person, the process, and the product all alluded to in the above definitions, what is missing is an acknowledgement of the environment within which creativity takes places. As we will discuss shortly, this element of environment holds importance when considering how to foster creativity in dental education. Combined, these four elements—the person, process, product, and press (or environment)—form the pillars of the 4 P's model of creativity (12).

2.2.1. A model of creativity

The 4 P's model of creativity has been the most widely adopted creativity framework since the 1960's (12), enabling researchers a structure to scaffold thinking and experimentation concerning creativity. In this model, the creative product is built by the creative person as the result of the creative process, while being supported in a creative environment (*Press*). Despite its widespread adoption, recent reflection on the model has questioned its individualistic vision of creativity. Given that dental education relies on interactive and context-dependent activities and prioritises the performative and relational aspects of the profession (including practitioner-patient interactions), we will take a more contextual and dynamic approach to considering creativity in tertiary education settings by adopting the 5 A's framework of creativity (13). This recent adaptation of the 4 P's model consists of five elements: actor, action, artifact, audience, and affordances.

A comparison of the two models shows similarities between each of the elements, although the focus of each differs slightly, with the relational or contextual aspect underscored in the 5 A's model (**Figure 1**). Comparing the models, the final element exhibits the greatest conceptual shift, with *Press*—referring to the "pressing" environmental influences that surround a creative person and their creative product—being divided into two separate categories in Glăveanu's 5A's model: *Audience* and *Affordances*. This division allows us to reflect more deeply on both the social and material environments that a creative dental educator (*Actor*) works with and in. Glăveanu's definition of the audience as "multiple others that assist, contribute, judge, criticise, or use the creative act and/or resulting artifact(s)" (p. 74) is an important distinction that aligns with the role of collaboration, for example through peer-review of teaching for dental educators (14). The *Affordances* of this model speaks to the environment in which educators work, and the role of leadership in fostering creativity in tertiary settings. Learning

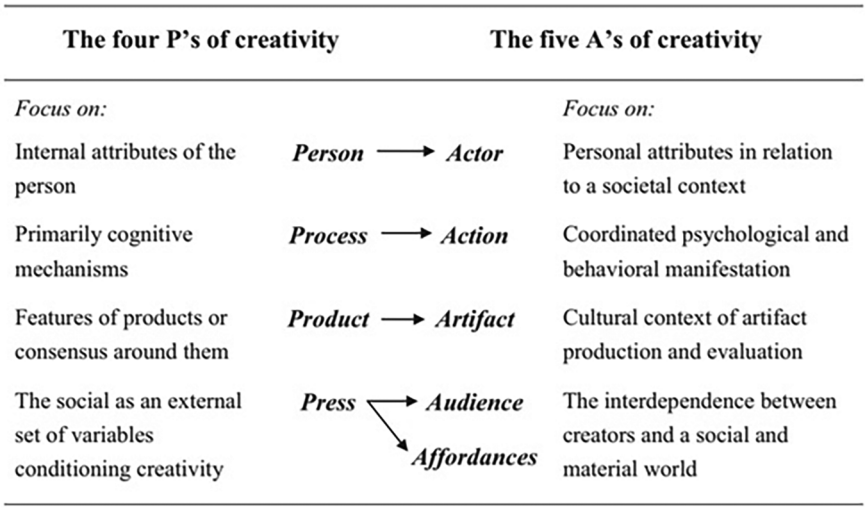

FIGURE 1
Comparing the four P's and the five A's frameworks (13). [Reprinted from Reviews of General Psychology, 17, Vlad Petre Glăveanu, Rewriting the Language of Creativity: The Five A's Framework, 69–81, Copyright (2012), with permission from SAGE].

environments require three key elements to be implemented to ensure creativity is fostered at a tertiary level: designing creative learning environments, facilitating student creativity, and modelling creative pedagogical practice (15). This involves embedding creativity at the level of the learning environment, the student, and the teacher, complementing Beghetto's assertion that creative teaching must include "teaching *about* creativity, teaching *for* creativity, and teaching *with* creativity" (16) (p. 549). We will now discuss the relationship between creativity of individuals and innovation in institutions, giving examples from dental education and relating these examples to the elements of the 5A's model. In doing so, we seek to identify the elements of this framework that appear most relevant for dental education, providing clues as to where leadership can focus their support for creativity and therefore innovation.

2.3. Factors facilitating creativity and innovation, and the implications for dental education

As described above, creativity is viewed as the generation of novel and useful ideas, with innovation being the implementation of these. Creativity of individuals and small groups, and innovation in the organisation are closely related (17). The relationship between the two is bidirectional and is based on a correspondence between the factors necessary for individual creativity (see *Actor* and *Action*, **Figure 1**), and those necessary for institutional innovation (**Figure 2**). The factors necessary for institutional innovation relate to the environment or the *Audience* and *Affordances* of the 5A's model of creativity (**Figure 1**).

Individual creativity requires a concurrence of motivation to do the task, expertise in the relevant domain, and creative thinking (17). The COVID-19 pandemic provided the perfect case-study to illustrate the interrelationships between the creativity of dental educators and innovation in educational institutions (18). Educators were motivated to continue teaching and assessing students online enabling them to combine pedagogical and content expertise and creative thinking to develop solutions to students not being able to attend in-person classes (19). These innovations were only successful because educational institutions were open to changing the way students were taught and assessed (20), could manage this innovation, and provided the necessary physical and technological resources.

2.3.1. Expertise in the relevant domain

Our expertise or knowledge is the foundation of our creativity, because new ideas are built on old ideas (21). However, the complexity of problems faced by organisations often necessitates expertise across multiple domains to generate new ideas (17). A useful framework for conceptualising the expertise required of dental educators is the Technological Pedagogical Content Knowledge (TAPCK) framework (22) which illustrates that content, pedagogy and technology must be integrated for effective teaching in the digital age (23).

As dental educators, we come to our roles often because of our content knowledge. However, the challenges facing dental educators may require knowledge across multiple content areas. In their recent discussion of the implications of healthcare challenges towards 2040 on dental education, Reddy and Hughes describe the need to integrate clinical, biomedical, population health and behavioural sciences in dental curricula (24), which requires content knowledge across multiple domains. Such integration of diverse content knowledge can be supported by developing teaching teams from multiple disciplines (25). This has particular relevance for developing interprofessional learning opportunities for oral health professional students. To complement content expertise, knowledge of how students learn

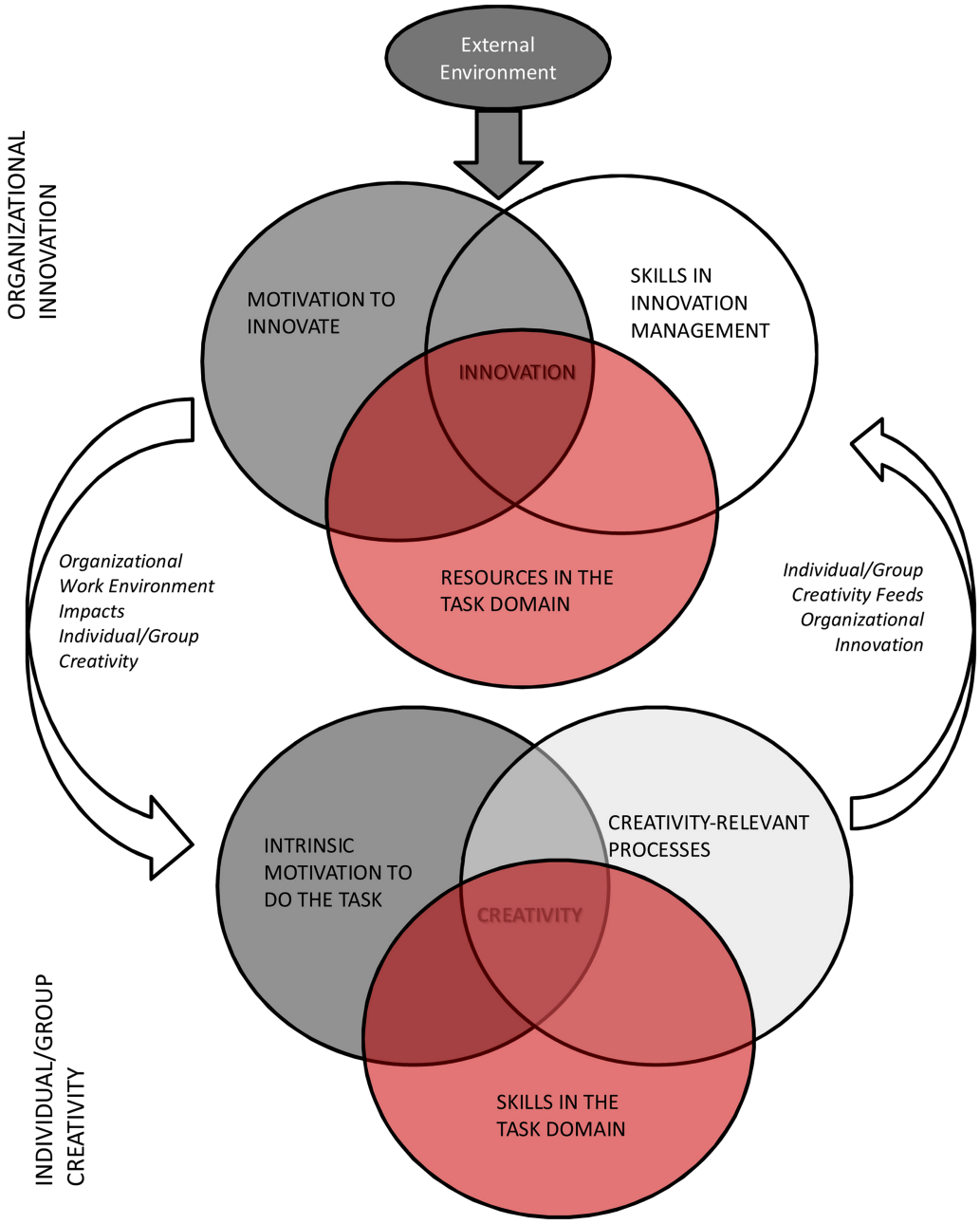

FIGURE 2
Components influencing innovation and creativity (17). [Reprinted from Research in Organizational Behavior, Vol 36, Amabile TM and Pratt MG, The Dynamic componential model of creativity and innovation in organizations: Making progress, making meaning, 157–183, Copyright (2016), with permission from Elsevier].

is vital for dental educators. In a study of professional development in emerging pedagogies, collaborative development of pedagogical knowledge among dental educators was found to support the implementation of teaching innovation, with a lack of pedagogical knowledge acting as a barrier to adoption of innovative pedagogies (23). Mloka and colleagues reported a similar relationship between pedagogical knowledge and innovation even under challenging circumstances of increasing student numbers, high teaching loads and curriculum change (26). A lack of technological knowledge impedes innovation. Whilst dental educators have been employing a diverse range of technological tools in teaching for decades, barriers to the use of such tools in dental education include the need to understand new and complex technologies and how these can be incorporated into teaching practice (27) and a lack of familiarity with available tools (28). Educators need to understand how to utilise technologies to improve student learning. Employing an innovative self-study methodology, Leadbeatter and colleagues

describe the collaborative development of technological knowledge that enabled them to understand technology as dental educators (29). Collectively, this indicates that to support the creativity of dental educators, institutions must encourage staff to work collaboratively to share and build their knowledge across relevant domains of content, pedagogy and technology. The implication for leadership is investment in dental educators as the creative *Actor*.

2.3.2. Creativity-relevant processes

Whilst knowledge is vital for creativity, it can stifle innovation in the absence of creative thinking skills (30). Creative problem solving requires a combination of cognitive processes including problem definition, generation of new ideas, both divergent and convergent thinking (31), thinking broadly, and making unusual associations (18). Methods by which dental educators have demonstrated development of these creativity-relevant cognitive processes include design thinking, scenario planning and establishing professional learning communities. Design thinking is a problem-solving framework which encourages participants to work collaboratively with an open mind and suspension of judgement (32). Wolcott and colleagues recently employed a design thinking approach when leading dental faculty to the development of an innovative dental curriculum (33). Design thinking has also been suggested as an ideal approach for designing dental teaching clinics of the future (3). Scenario planning involves responding to hypothetical "what if" questions to create alternative futures (34). In a recent description of scenario planning in dental education, this method enabled educators to explore new ideas in relation to challenges in dental education including interprofessional collaborative practice, diversity and equity, access to dental care, and advocacy to enhance global oral health outcomes (34). Reviewing the proposed evaluation of scenario planning in dental education, Horvath and Quick describe that through engaging with this activity, educators can develop their creative thinking skills such as generating ideas for other contexts to address the challenges proposed by the scenario planning activity (35).

A professional learning community is a group of people who share and reflect on their practice with the view to grow and learn (36). Reflecting on how this definition relates to the 5A's model of creativity, each member of a professional learning community could be considered both as *Actor* and *Audience*. In a discussion of change management in dental education, Palatta proposes that participation in professional learning communities may enable creative thinking in dental educators (37). Whilst not explicitly identified as a professional learning community, the collaborative self-study approach of Leadbeatter and colleagues demonstrates characteristics of such a community. Exploring their approach (29), creativity-relevant processes are abundantly evident including considering new perspectives on problems and making unusual associations (17). An added benefit of a professional learning community may be a positive impact on the satisfaction and morale of dental educators (37). Therefore, returning to the 5A's model of creativity, design thinking, scenario planning, and the development of professional learning communities are collaborative *Affordances* which may enable the development of creativity-relevant attributes of dental educators who each play a dual role as *Actor* and *Audience*.

2.3.3. Motivation

Motivation, particularly intrinsic motivation, is vital for creativity (38). Self-determination theory proposes that satisfying the three basic psychological needs for competence, autonomy and relatedness will enhance motivation (39). This suggests that educators need to believe they have the requisite knowledge and skills, have choice in how they enact their role, and a sense of belonging to a community with similar goals (38) in order to develop innovative solutions to the challenges facing dental education into the future. This aligns with the importance of developing pedagogical knowledge as illustrated by the TPACK framework discussed above. To see this in action, as we saw earlier, in a study of the impact of a professional development program to support the development of pedagogical knowledge, followed by formation of a learning community, dental educators reported they were motivated to improve their teaching practice, with reports of implementation of innovative teaching strategies (23). In a recent systematic review of the use of digital technologies in dental education, Zitzmann and colleagues assert that a high level of motivation is needed for educators to embrace an implement innovative digital technologies (40) and speculate that the digital infrastructure and the level of innovation of educators will be included in the raking of dental schools (40). Therefore, this combination of intrinsic and extrinsic motivation relates to both the *Actor* and *Affordances* of the 5A's model of creativity.

2.3.4. Institutional factors

To this point, we have focused on factors that can enhance the creativity of individuals and teams of educators, and provided examples of how this can influence innovation in dental education. To support creativity and innovation we also need to look to contextual factors in organisations (7), which are conceptualised by Amabile and Pratt (2016) as motivation to innovate, relevant resources, and skills in innovation management (**Figure 2**) (17). These factors clearly align with *Affordance* in the 5A's model of creativity. Resources include financing for projects, infrastructure with the necessary materials and services, and enabling sufficient time to explore and implement creative solutions (17). For example, MacNeill and Hilario suggest that clinical placement operations that do not enable students from different health professions to interact and engage in integrated patient care is inhibiting interprofessional education (IPE) across dental schools in the US. They further suggest that dental schools need to explore external, community-based models of care to enable authentic interprofessional learning experiences (41). Such a solution requires resourcing in the form of time, financing and developing the appropriate

model of care. A successful example of this can be found in a community-based IPE program that enabled nursing and dental students to engage in a collaborative care program, and successfully increased the oral health knowledge of program participants (42). Lack of various resources have been reported as barriers to implementing online learning in dental education. Over a decade has passed since Shonwetter and colleagues reported the greatest impediments to innovation in online learning in dentistry were institutional, including financial cost, technical support required, politics and a stakeholder resistance to change (27), highlighting the need for institutional support for innovation. Time or lack thereof is repeatedly reported as a barrier to implementing innovative pedagogies (28, 37, 43). Institutions must value the time it takes to develop and implement innovative approaches to dental education.

3. Conclusion

Through the examples outlined in this article, we demonstrate that some dental educators are leading the way in curriculum innovation, and that this is related to various elements of creativity. However, to continue developing innovative pedagogical practices and to address future challenges in dental education, more action is needed. Just as '*Action*' refers to coordinated psychological and behavioral manifestations in the model of creativity used to scaffold this discussion, we call on leadership in dental education to coordinate action to enable environments which foster and value creativity.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Watt RG, Daly B, Allison P, Macpherson LM, Venturelli R, Listl S, et al. Ending the neglect of global oral health: time for radical action. *Lancet*. (2019) 394 (10194):261–72. doi: 10.1016/S0140-6736(19)31133-X

2. Thurzo A, Strunga M, Urban R, Surovková J, Afrashtehfar KI. Impact of artificial intelligence on dental education: a review and guide for curriculum update. *Educ Sci*. (2023) 13(2):1–14. doi: 10.3390/educsci13020150

3. Dragan IF, Walji M, Vervoorn M, Quinn B, Johnson L, Davis J, et al. ADEA-ADEE Shaping the future of dental education III. *J Dent Educ*. (2020) 84(1):111–6. doi: 10.1002/jdd.12027

4. Duane B, Dixon J, Ambibola G, Aldana C, Couglan J, Henao D, et al. Embedding environmental sustainability within the modern dental curriculum—exploring current practice and developing a shared understanding. *Eur J Dent Educ*. (2021) 25(3):541–9. doi: 10.1111/eje.12631

5. Field J, Martin N, Duane B, Vital S, Mulligan S, Livny A, et al. Embedding environmental sustainability within oral health professional curricula—recommendations for teaching and assessment of learning outcomes. *Eur J Dent Educ*. (2023) 27:650–61. doi: 10.1111/eje.12852

6. Saeed SG. Combating sexism—the need for real inclusion in dental education. *eJACD*. (2021) 18:18–24.

7. Anderson N, Potocnik K, Jing Z. Innovation and creativity in organizations: a state-of-the-science review, prospective commentary, and guiding framework. *J Manag*. (2014) 40:1297.

8. Hennessey BA, Amabile TM. Creativity. *Annu Rev Psychol*. (2009) 61(1):569–98. doi: 10.1146/annurev.psych.093008.100416

9. Rank J, Pace VL, Frese M. Three avenues for future research on creativity. Innovation, and Initiative. *Appl Psychol*. (2004) 53(4):518–28. doi: 10.1111/j.1464-0597.2004.00185.x

10. American Psychological Association. (n.d.). Creativity. In APA dictionary of psychology. Available at: https://dictionary.apa.org/creativity (Retrieved April 04, 2023).

11. Colman AM. *A dictionary of psychology*. 4 edn. Oxford, UK: Oxford University Press (2015).

12. Rhodes M. An analysis of creativity. *The Phi Delta Kappan*. (1961) 42:305–10.

13. Gla˘veanu VP. Rewriting the language of creativity: the five a's framework. *Rev Gen Psychol*. (2013) 17(1):69–81. doi: 10.1037/a0029528

14. Cunningham I, Johnson I, Lynch C. Implementing peer review of teaching: a guide for dental educators. *Br Dent J*. (2017) 222(7):535–40. doi: 10.1038/sj.bdj.2017.316

15. Cochrane T, Antonczak L. Designing creative learning environments. *Interact Des Architect*. (2015) 24:125–44. doi: 10.55612/s-5002-024-008

16. Beghetto RA. Creativity in teaching. In: Kaufman JC, Baer J, Glăveanu VP, editors. *The Cambridge handbook of creativity across domains. Cambridge handbooks in psychology*. Cambridge: Cambridge University Press (2017). p. 549–64.

17. Amabile TM, Pratt MG. The dynamic componential model of creativity and innovation in organizations: making progress, making meaning. *Res Organ Behav*. (2016) 36:157–83. doi: 10.1016/j.riob.2016.10.001

18. Kerkstra RL, Rustagi KA, Grimshaw AA, Minges KE. Dental education practices during COVID-19: a scoping review. *J Dent Educ*. (2022) 86(5):546–73. doi: 10.1002/jdd.12849

19. Boyer KR, Chui BS, Ywom J, Farah-Franco SM. Teaching preclinical endodontics virtually. *J Dent Educ*. (2020) 84. doi: 10.1002/jdd.12238

20. Saeed SG, Bain J, Khoo E, Siqueira WL. COVID-19: finding silver linings for dental education. *J Dent Educ*. (2020) 84(10):1060–3. doi: 10.1002/jdd.12234

21. Weisberg RW. Creativity: what it is. In: Weisberg RW, editors. *Rethinking creativity: Inside-the-box thinking as the basis for innovation*. Cambridge: Cambridge University Press (2020). p. 41–72.

22. Mishra P, Koehler MJ. Technological pedagogical content knowledge: a framework for teacher knowledge. *Teach Coll Rec*. (2006) 108:1017. doi: 10.1111/j.1467-9620.2006.00684.x

23. Zheng M, Bender D, Nadershahi N. Faculty professional development in emergent pedagogies for instructional innovation in dental education. *Eur J Dent Educ*. (2017) 21(2):67–78. doi: 10.1111/eje.12180

24. Reddy M, Hughes S. Dental education: but not as we know it. *J Calif Dent Assoc*. (2020) 48(3):133–8. doi: 10.1080/19424396.2020.12222559

25. Mays KA. Designing oral health curriculum that facilitates greater integration of oral health into overall health. *Front Dent Med*. (2021) 2:1–6. doi: 10.3389/fdmed.2021.680520

26. Mloka DA, Omer S, Mkony CA, Kisenge RR, Macfarlane SB, O'Sullivan PS. Health professions educators as agents of change in Tanzania: creativity to implement new curricula. *J Public Health Policy*. (2012) 33:s171–s85. doi: 10.1057/jphp.2012.46

27. Schonwetter DJ, Reynolds PA, Eaton KA, De Vries J. Online learning in dentistry: an overview of the future direction for dental education. *J Oral Rehabil*. (2010) 37(12):927. doi: 10.1111/j.1365-2842.2010.02122.x

28. Schönwetter D, Reynolds P. Discovering online learning barriers: survey of health educational stakeholders in dentistry. *Eur J Dent Educ*. (2013) 17(1):e126–e35. doi: 10.1111/j.1600-0579.2012.00772.x

29. Leadbeatter D, Lansdown K, Terry A, Dracopoulos S. Using self-study as a methodology for dental educators' professional inquiry. *Eur J Dent Educ*. (2021) 25(2):310–7. doi: 10.1111/eje.12606

30. Sternberg RJ. Enhancing people's creativity. In: Kaufman JC, Sternberg RJ, editors. *The Cambridge handbook of creativity. Cambridge handbooks in psychology*. 2 ed. Cambridge: Cambridge University Press (2019). p. 88–104.

31. Mumford MD, McIntosh T. Creative thinking processes: the past and the future. *J Creat Behav*. (2017) 51(4):317–22. doi: 10.1002/jocb.197

32. McLaughlin JE, Wolcott MD, Hubbard D, Umstead K, Rider TR. A qualitative review of the design thinking framework in health professions education. *BMC Med Educ*. (2019) 19(1):1–8. doi: 10.1186/s12909-019-1528-8

33. Wolcott MD, Mason MR, Broome AM, Tittemore AJ, De Rossi SS, Quinonez RB. Faculty perspectives of an entrustable professional activity (EPA) framework in predoctoral dental education. *J Dent Educ*. (2020) 84(9):955–63. doi: 10.1002/jdd.12373

34. Haden NK, Bell KP, Bottino MC, Haley CM, Quick KK, Yelick PC. Dental education 2026: a scenario exploration. *J Dent Educ*. (2022) 86(3):343–51. doi: 10.1002/jdd.12838

35. Horvath Z, Quick KK. Scenario user guide. *J Dent Educ*. (2021) 85:1–5. doi: 10.1002/jdd.12840

36. Stoll L, Bolam R, McMahon A, Wallace M, Thomas S. Professional learning communities: a review of the literature. *J Educ Change*. (2006) 7(4):221–58. doi: 10.1007/s10833-006-0001-8

37. Palatta AM. Change management in dental education: a professional learning community. *J Dent Educ*. (2018) 82(6):549–56. doi: 10.21815/JDE.018.061

38. Hennessey BA. Motivation and creativity. In: Kaufman JC, Sternberg RJ, editors. *The Cambridge handbook of creativity. Cambridge handbooks in psychology*. 2 ed. Cambridge: Cambridge University Press (2019). p. 374–95.

39. Deci EL, Ryan RM. Self-Determination theory: a macrotheory of human motivation, development, and health. *Can Psychol*. (2008) 49:182. doi: 10.1037/a0012801

40. Zitzmann NU, Matthisson L, Ohla H, Joda T. Digital undergraduate education in dentistry: a systematic review. *International journal of environmental research and public health*. Switzerland: MDPI (2020).

41. MacNeil RL, Hilario H. Input from practice: reshaping dental education for integrated patient care. *Front Oral Health*. (2021) 2:1–7. doi: 10.3389/froh.2021.659030

42. Greenberg SA, Hartnett E, Berkowitz GS, Schenkel AB, Chong C, Cipollina J, et al. Senior oral health: a community-based, interprofessional educational experience for nursing and dental students. *J Gerontol Nurs*. (2020) 46(8):37–45. doi: 10.3928/00989134-20200527-03

43. Jambi S, Khalifah AM, Fadel HT. Shifting from traditional lecturing to interactive learning in Saudi dental schools: how important is staff development? *J Taibah Univ Medi Sci*. (2015) 10(1):45–9. doi: 10.1016/j.jtumed.2015.01.004

frontiers | Frontiers in Medicine

TYPE Original Research
PUBLISHED 08 January 2024
DOI 10.3389/fmed.2023.1323183

OPEN ACCESS

EDITED BY
Melanie Nasseripour,
King's College London, United Kingdom

REVIEWED BY
Yifang Ma,
Southern University of Science and Technology, China
Satyam Mukherjee,
Shiv Nadar University, India

*CORRESPONDENCE
Siqi Luo
✉ 597478463@qq.com
Tao Luo
✉ 2011686028@gzhmu.edu.cn

†These authors have contributed equally to this work and share first authorship

RECEIVED 17 October 2023
ACCEPTED 21 December 2023
PUBLISHED 08 January 2024

CITATION
Miao X, Chen X, Li J, Wu Z, Guo L, Luo S, Luo T and Yang X (2024) Enhancing undergraduate research talents: the role of tutors in dental basic research education. *Front. Med.* 10:1323183. doi: 10.3389/fmed.2023.1323183

Enhancing undergraduate research talents: the role of tutors in dental basic research education

Xiaoyu Miao[1†], Xuanyu Chen[1†], Jiayi Li[1], Zhe Wu[2], Lvhua Guo[2], Siqi Luo[2*], Tao Luo[2*] and Xuesong Yang[3,4]

[1]School of Stomatology, Guangzhou Medical University, Guangzhou, China, [2]Department of Prosthodontics, Guangzhou Key Laboratory of Basic and Applied Research of Oral Regenerative Medicine, Guangdong Engineering Research Center of Oral Restoration and Reconstruction, Affiliated Stomatology Hospital of Guangzhou Medical University, Guangzhou, China, [3]Clinical Research Center, Clifford Hospital, Guangzhou, China, [4]Division of Histology and Embryology, Medical College, Jinan University, Guangzhou, China

Purpose: This study endeavors to investigate ways to optimize the role of teachers in undergraduate dental basic research education (UDBRE) with the aim of nurturing the research potential of undergraduate students.

Methods: We conducted a cross-sectional study among medical undergraduates enrolled at the School of Stomatology, Guangzhou Medical University. Descriptive statistics were employed to comprehensively analyze UDBRE's fundamental aspects. Kendall rank correlation analysis was performed to evaluate the relationship between the quality of feedback provided by tutors to undergraduates and the students' scientific research abilities. Additionally, multivariate logistic regression analysis was employed to uncover the factors influencing the effectiveness of UDBRE.

Results: A total of 168 medical students were surveyed with a valid response rate of 93.85%. The effectiveness of UDBRE was demonstrated by undergraduates' self-rated research abilities, active participation in scientific research projects, and a certain amount of academic outputs. Significant and positive correlations ($\mathcal{T}_b > 0.5$, $p < 0.001$) were identified between the tutor-undergraduate feedback quality and students' self-rated scores for scientific research abilities. These abilities included developing scientific questions, designing research projects, retrieving and reading literature, academic writing, experiment operation, and analyzing and evaluating experimental results. Positive effects on students' academic performance ($p < 0.05$) were observed when higher-quality feedback, an authoritative tutoring style and tutors with middle-career experience were present.

Conclusion: This study underscores the pivotal role of UDBRE in fostering the scientific research aptitude of medical undergraduates. It emphasizes the constructive influence of tutor-undergraduate feedback, authoritative teaching styles, providing valuable insights for establishing an effective mentorship framework.

KEYWORDS

mentorship, medical education, feedback, academic performance, scientific research

Introduction

In an era marked by an explosion of information, it is imperative that medical students acquire the ability to critically assess scientific papers (1). To achieve this goal, it is paramount for them to comprehend the origins of information and systematically evaluate pertinent studies. The idea of embedding research into the dental curriculum dates back to 1926 (2). Engaging in research during collegiate education can foster active learning and critical thinking, enabling students to identify scientific challenges in routine clinical practice. Opportunities for research projects have been extended to dental graduates to champion dental advancements in European and American countries, as well as China (3–5). However, a significant proportion of dental graduates gravitate towards private practice rather than a research career (6). To bolster student engagement in scientific research, various strategies have been proposed during undergraduate studies (7). The concept of "Undergraduate Dental Basic Research Education (UDBRE)" has been globally embraced in curricula, with UDBRE designed to cultivate research interest and inspire creativity in students' future careers (8, 9).

Typically UDBRE refers to a pedagogical strategy that integrates theoretical coursework with active participation in mentor-guided student research projects and hands-on training in experimental techniques (9). A standard paradigm has been outlined by Eryi Lu (10). Under the premise of two-way selection between tutors and students, highly professional and morally excellent teachers are appointed as tutors for undergraduate students, providing individual guidance on their academic studies, and grant drafting. Undergraduate student tutor and student communicate regularly and student report prepared work on literature reading, reading and essays. UDBRE plays a vital role in guiding students through scientific projects, and providing invaluable assistance, suggestions, and guidance for students' research ideas and designs (9). This approach not only stimulates intellectual curiosity and latent capabilities but also fosters the early development of research acumen and skills (11, 12). The primary objective of the present study is to assess the effectiveness of UDBRE using both objective measures of academic performance and a questionnaire designed to evaluate academic capabilities.

The paradigm of undergraduate training with a focus on academic research has ushered in a significant shift from a teacher-centered approach to a more student-centered educational model (13, 14). This transition towards a student-centered approach may sometimes result in minimal intervention, potentially leading to a neglectful tutor style. Within this context, scholars have advocated for the incorporation of dialogic approaches, characterized by open and interactive dialogues between tutors and students, followed by authoritative interventions within the realm of scientific training (15). However, the influence of tutor style on students' research abilities remains an area yet to be fully explored.

Furthermore, scientific abilities encompass a broad spectrum of proficiencies, ranging from proficient literature comprehension and refined academic writing to the skillful execution of experiments and more. These demands pose significant challenges for students, especially as they must balance these requirements with their dental studies (16). This challenge becomes particularly pronounced for Chinese students who often grapple with materials predominantly presented in English (17). Therefore, it is imperative to approach student involvement in research with a heightened emphasis on promoting self-motivated engagement. The attitudes and teaching methodologies of instructors are closely linked to shaping students' levels of motivation (18). Negative attitudes demonstrated by educators have been found to correlate with reduced student motivation (19). Rather than adopting a narrow focus solely on evaluating the accuracy of students' work or appraising their aptitudes, an effective approach hinges on the provision of constructive feedback. This approach entails imparting informative feedback that not only affirms students' accomplishments but also highlights areas where improvements can be made. This practice offers the dual benefit of bolstering students' self-assurance and fostering the refinement of their skill sets (20). The feedback-driven approach also contributes to the cultivation of a robust sense of self-assuredness among students while simultaneously enhancing their competencies. Therefore, the second aim of this study is to explore the relationship between feedback given by students and teachers.

In order to provide effective guidance in UDBRE and meet the mentorship needs of students participating in UDBRE, it is crucial to identify more successful forms of mentoring and cost-effective improvements, especially within large research universities. To address this, we conducted a cross-sectional survey aimed at confirming the effectiveness of UDBRE and further investigating a series of indicators, including feedback from both tutors and students, tutoring styles, and career experience. The goal is to determine whether these indicators can signify a successful mentoring relationship, thereby contributing to the reform and development of UDBRE in colleges and universities.

Methods

Description of UDBRE

UDBRE have been piloted since 2016 to now in School of Stomatology, Guangzhou Medical University. The primary objective of this dental undergraduate research program is to promote and facilitate undergraduate students' engagement in drafting and applying for research grants, conducting research, and publishing peer-reviewed papers. The initial step involved soliciting faculty members from the School of Stomatology Guangzhou Medical University to volunteer as mentors for students. Subsequently, a list of willing mentors was provided to students, initiating a two-way selection process between tutors and students. To equip students with the necessary skills and knowledge, a dedicated course on innovation experiments was integrated into the curriculum during the third grade. This course covered fundamental concepts essential for fostering basic research and innovation skills, including topics such as research subject exploration, research methodology, literature review techniques, experimental design and execution, data analysis, and academic writing. As part of this course, students were tasked with preparing a research grant proposal and a research paper. Furthermore, they were strongly encouraged to actively apply for research grants and submit their papers to peer-reviewed journals, all under the expert guidance of their assigned tutors. Each research tutor is obligated to provide continuous mentorship to undergraduate students, ensuring that academic achievements are submitted and that students have the opportunity to present their research findings effectively.

Participants and ethics approval

From 2016 to the present, a total of 311 undergraduate students enrolled in the School of Stomatology at Guangzhou Medical University actively participated in the Undergraduate Dental Basic Research Education (UDBRE) program. To comprehensively assess the impact of this training initiative, we analyzed their achievements, including published papers, approved research grants, and awards. Additionally, we conducted a cross-sectional survey among 179 undergraduate students who were in their third year or higher, utilizing a questionnaire to gain insights into their experiences and perceptions related to UDBRE. 168 (93.85%) of students responded with complete answers. Prior to their participation in the study, each student was provided with a comprehensive information sheet outlining the study's purpose, objectives, the nature of their involvement, the expected duration of participation, potential risks and benefits, and details regarding data confidentiality. It was made explicit that the information provided would not be shared with their teachers, nor used to assess their abilities to prevent potential bias. Each student was required to read the information sheet thoroughly to ensure a clear understanding of their involvement. Subsequently, they provided written informed consent indicating their voluntary agreement to participate in the study. The proposal for this study was approved by the institutional ethics committee of Guangzhou Medical University (Ref No. LCYJ2023019).

Questionnaire design

The questionnaire was designed to consist of 29 items and contain three sections in Chinese, including basic information, the academic outcome and self-rated scientific research competency of undergraduates.

In section one, characteristic data of the participating undergraduates was collected including gender of undergraduates, grade, the tutoring style, the tutor's career experience, the average tutoring time. The definition of 4 types of tutoring style is based on existing literature and presented in the form of a multiple-choice question, allowing students to select the most suitable type based on their actual experiences (21). The authoritative tutor is characterized by a high level of demandingness and expectations, coupled with an active involvement in student's learning. The authoritarian style entails high levels of demandingness but low levels of involvement, whereas the permissive style displays the inverse with high involvement but low demandingness. The average tutoring time included mentorship conducted by online meetings, face-to-face interactions, and other means.

The second section targeted the correlation relationship between the tutor-undergraduate feedback quality and undergraduates' scientific research abilities. Feedback quality between tutors and undergraduates was evaluated using a 5-point Likert scale ranging from 1 (strongly disagree) through 3 (neutral) to 5 (strongly agree). Based on existing literature (22), this self-made scale comprised 6 items grouped under two dimensions, named "feedback quality of tutors" and "feedback quality of undergraduates." A 5-point Likert scale was administered to the interviewees to learn their own perception of the development of their academic and research skills including scientific questions developing, scientific research projects design, literature retrieving and reading, academic writing, experimental operation and experimental results analyzing and evaluating. And the scale ranged from 1 (strongly disagree) to 5 (strongly agree).

As the goal of UDBRE in Guangzhou Medical University is to instruct students to publish academic papers and applying for funded research projects of variety of kinds, the last section reflected the academic outcome of participated undergraduates including completed academic paper drafts, published papers as first or co-first authors, funded research projects and awards in competition. Completed article draft is a shorter-term indicator of academic performance. In the evaluation of published academic achievements, the students provided the number of papers as first authors or co-first authors, which had been published. As for funded research projects, we counted the number of the students who presided or participated in scientific research projects mainly including the National College Students Innovative Training Program and College Students Innovative Training Program of Guangdong Province. Competitions, such as the China College Students' "Internet plus" Innovation and Entrepreneurship Competition and the "Challenge Cup" College Students' Extracurricular Academic Science and Technology Works Competition, were included for a descriptive analysis of UDBRE. The number of completed academic paper drafts, published research articles, and funded research projects were taken as dependent variables of multiple logistic regression analysis. Each item was graded as 1, none; 2, one; and 3, two or more. At last, an open-ended question was used to gather detailed thoughts from students about their UDBRE participation.

Questionnaire reliability and validity analysis

The complete questionnaire was meticulously reviewed for relevance, comprehensiveness, as well as face and content validity prior to the commencement of data collection. Pilot testing was also done among 30 students to ensure clarity of the content of the questionnaire. The internal consistency reliability test was performed to ensure the overall reliability of the questionnaire. Cronbach's α coefficients for the tutor-undergraduate feedback scale and scientific research ability scale were 0.892 and 0.967, respectively, which exceeded the commonly used threshold of 0.7 for good reliability. Exploratory factor analysis (EFA) was performed to specify the structure and underlying dimensions of the scale. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's sphericity test were performed to assess the eligibility to EFA. The EFA was conducted through the principal component analysis to extract the main factors may contribute to the variance in the overall samples from 6 items based on the eigenvalue>1. Varimax Kaiser normalization was used to rotate the factor load matrix. The KMO coefficient of scientific research ability scale was 0.928 and Bartlett's sphericity test was statistically significant ($\chi^2 = 1506.072$, $p < 0.001$), which indicated a well-constructed structure.

Statistical analysis

Descriptive statistics for this data was presented as number, constituent ratio and mean ± standard deviation (SD). The average

points of the Likert scores for each item/factor were presented as the mean ± SD. Multivariate ordinal logistic regressions were used to find the associated factors for completed academic paper drafts, published papers and funded research projects of undergraduates. The test of parallel lines is used in the context of analysis of variance (ANOVA) or analysis of covariance (ANCOVA) to examine if the slopes of multiple regression lines are parallel. The Kendall rank correlation analysis was applied to evaluate correlation between the tutor-undergraduate feedback quality and the undergraduates' self-perceived scientific research abilities. Graphical analysis of descriptive data was conducted using GraphPad Prism 9 software version 9.5.0 (La Jolla, CA, Unites States). Data were analyzed using SPSS version 25.0 (IBM, Unites States) and $p < 0.05$ was considered a statistically significant difference.

Result

Basic information of participants

The basic information of participants is shown in Table 1. 92 (54.76%) participants were male and 76 (45.24%) were female. A total of 63 (37.50%) students were from the third grade, 49 (29.17%) were from the fourth grade and 56 (33.33%) were from the fifth grade. As for the average weekly tutoring time, over half of students (N = 87, 51.79%) were received mentorship of less than 15 min. 71 (42.26%) students had scientific projects approved, but the number decreased to 61 (36.31%) and 43 (25.60%) when it comes to students with academic paper drafts for publication and published articles as first or co-first authors, respectively.

Descriptive analysis of the academic outcome of undergraduates since UBDRE implementation

From 2016 to 2022, undergraduates participating in UDBRE achieved notable academic milestones, which encompassed publications in peer-reviewed journals, successful grant-funded research projects, and recognition through awards in innovation and entrepreneurship competitions. The findings underscored a consistent upward trajectory in the number of research papers authored by undergraduates, whether as independent first authors or co-first authors. This journey commenced with just one paper in 2016 and culminated in an impressive 11 papers in 2021, as illustrated in Figure 1A. Consequently, by 2022, the total count of research papers authored by UDBRE students had reached a commendable tally of 30. It is noteworthy that the majority of these publications were comprised of reviews and original research articles, constituting 14 (46.67%) each of the total count, as depicted in Figure 1B.

Furthermore, we documented the involvement of undergraduate students in funded research projects and innovation and entrepreneurship competitions. Over the years, the number of research projects funded for undergraduates maintained a relatively high and stable level (Figure 1C). And it achieved a new breakthrough in 2022, reaching a total of 15 projects. This significant progress could be largely attributed to the students' participation in the introduced enhancement program. In total, undergraduates had actively participated in 64 research projects from 2016 to 2022. Regarding the number of awards obtained by undergraduates in innovation and entrepreneurship competitions, although this figure experienced a decline in 2021 and 2022, students collectively won 14 awards.

Exploratory factor analysis of the tutor-undergraduate scale

The results of the EFA indicated that the scale demonstrated good structural validity. A total of six items were subjected to exploratory factor analysis (Table 2). The KMO coefficient was 0.843, approaching 1, which indicated that the data were suitable for EFA. Additionally, Bartlett's sphericity test was statistically significant ($\chi^2 = 649.21$, $p < 0.001$) allowing the EFA to be performed (23). Two common factors were extracted using principal component analysis, which accounted for a cumulative variance explained rate of 84.30%. This indicated that these factors could explain 84.30% of all items and

TABLE 1 Basic information of participants.

Characteristic	Number (*N*)	Constituent ratio (%)
Gender of undergraduates		
Male	92	54.76
Female	76	45.24
Grade		
Third grade	63	37.50
Fourth grade	49	29.17
Fifth grade	56	33.33
Career experience		
Late career (>10 years)	40	23.81
Middle career (6–10 years)	62	36.90
Early career (<6 years)	66	39.29
Tutoring style		
Authoritative	61	36.31
Authoritarian	19	11.31
Permissive	46	27.38
Neglectful	42	25.00
Average weekly tutoring time		
≥15 min	81	48.21
<15 min	87	51.79
With funded scientific projects		
Yes	71	42.26
No	97	57.74
With completed academic paper drafts		
Yes	61	36.31
No	107	63.69
With published articles		
Yes	43	25.60
No	125	74.40

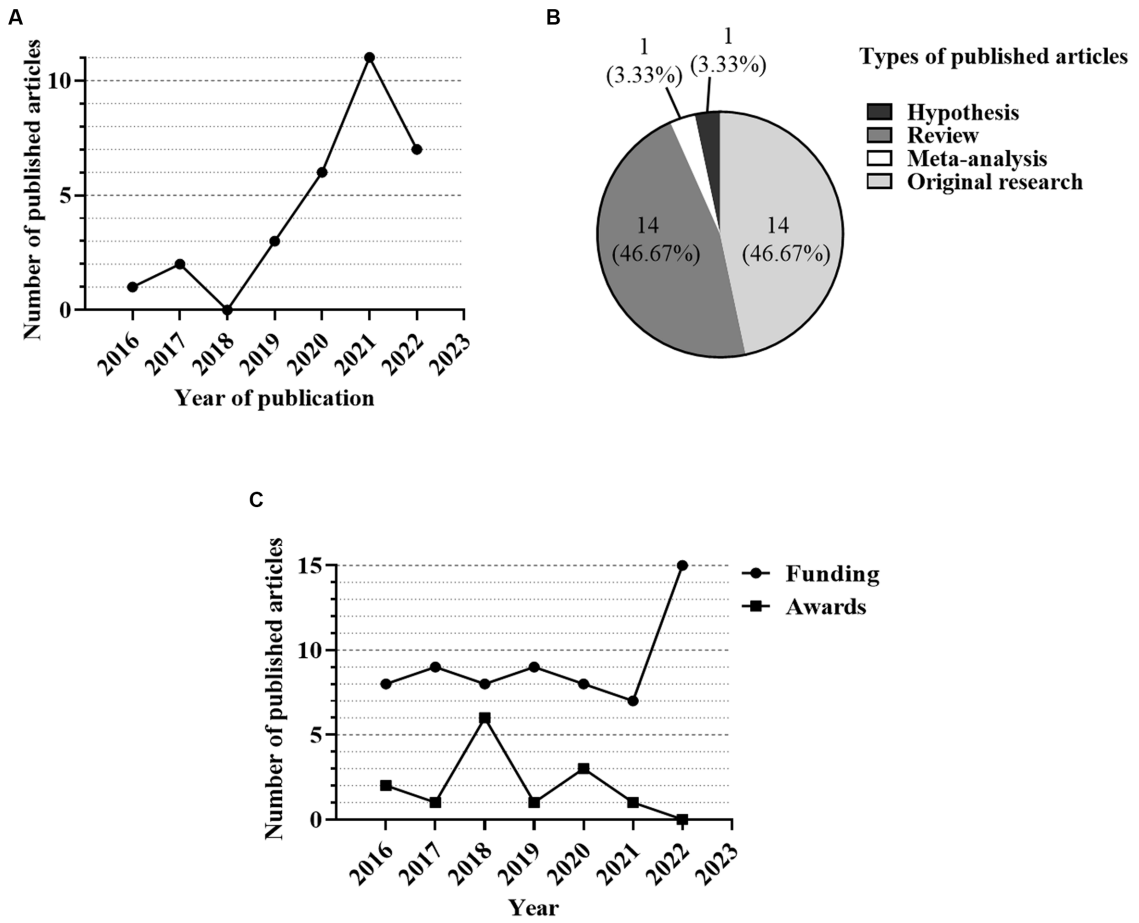

FIGURE 1
Academic outcome of undergraduates in UDBRE from 2016 to 2022. **(A)** The number of published articles by undergraduates as first authors or co-authors over the years. **(B)** Types of published articles. **(C)** The number of funded research projects and awards in competition obtained by undergraduates.

effectively capture most of the information conveyed by the indicators. Furthermore, all factor loading values exceeded 0.7, meeting the criteria for excellent factor loading (24). Therefore, the tutor-undergraduate feedback scale demonstrated good structural validity. The two dimensions identified through factor analysis were labeled as "Feedback quality of tutors" and "Feedback quality of undergraduates," representing the reciprocal feedback between tutors and undergraduates. The average scores for the feedback quality of tutors and undergraduates were 2.82 and 2.87, respectively.

Correlation analysis between the tutor-undergraduate feedback quality and scientific research ability

The evaluation of students' research abilities involved the use of a 5-point Likert scale. Kendall rank correlation analysis was then conducted to examine the relationship between the tutor-undergraduate feedback quality and students' research abilities (Table 3). The Kendall Tau-b coefficient ($\mathscr{T}_b$) was used to calculate correlation scores, ranging from 0 (indicating no correlation) to 1 (a complete correlation). The correlation coefficient between tutor-undergraduate feedback quality and scientific research ability was revealed to range from 0.543 to 0.660, which indicated that the survey items exhibited close correlations. Of note, the tutor-undergraduate feedback quality was most positively correlated with the ability of designing scientific projects ($\mathscr{T}_b = 0.660$ and 0.652 respectively), while the experimental operation skill showed weakest correlation ($\mathscr{T}_b = 0.522$ and 0.543 respectively).

Multivariate logistic regression analysis of influential factors of academic outcome

To investigate the influential factors of students' academic performance including the number of completed academic paper drafts, published articles, funded research projects, and interviewees' basic characteristics were taken as independent variables. The two dimensions of "feedback quality of tutors" and "feedback quality of undergraduates" were taken as continuous independent variables of multivariate logistic regression.

The result of the ordinal logistic regression analysis showed that the feedback quality of tutors and undergraduates, the tutoring style, and the career experience were significantly related to the student's completed academic paper draft (Table 4). The result of parallel line

TABLE 2 Exploratory factor analysis factor component matrix of tutor-undergraduate feedback scale.

Item	Factor loading	
	Factor 1: feedback quality of tutors	Factor 2: feedback quality of undergraduates
1. The tutor responds positively to your feedback	0.873	
2. The tutor can understand your feedback correctly	0.872	
3. The tutor's feedback can help solve your problem	0.853	
4. You often proactively give feedback to your tutor		0.796
5. You can provide feedback on your own issues accurately		0.860
6. You can provide continuous feedback to your tutor during the problem-solving process		0.893
n	3	3
Cronbach's α coefficient	0.879	0.893
Cumulative variance percent (%)	43.956	40.352
Score (mean ± SD)	2.82 ± 1.65	2.87 ± 1.47

Score: mean scores of each item of the factor; *n*: number of the related items of each factor; SD: standard deviation.

test was $p > 0.05$, rejecting the parallel lines assumption, which indicated that ordinal logistic model could be used. The odds ratio (OR) is used to quantify the strength and direction of the association between explaining variables and the specific dependent variable. It compares the odds of an event occurring in a subcategory group to the odds of the same event occurring in another subcategory group (reference category). When the OR is greater than 1, it indicates that the positive outcome is more likely to occur in the subcategory group compared to the reference group. In other words, there is a positive association between the subcategory group being studied and the dependent variable. The OR for explaining variables was adjusted for grade of undergraduates, which was considered a confounding factor. The result showed that high-quality feedback from tutors [OR = 1.898, 95% confidence interval (CI) 0.050–1.232, $p = 0.033$] and students (OR = 1.963, 95% CI 0.005–1.343, $p = 0.048$) both had a significant positive predictive effect on students' academic paper drafts. The result also indicated that authoritative tutors could positively influence academic achievements, with a 6.938 times higher likelihood of completing drafts compared to neglectful tutors (OR = 6.938, 95% CI 0.368–3.506, $p = 0.016$). Moreover, students with mid-career tutors (OR = 5.476, 95% CI 0.459–2.942, $p = 0.007$) were 5.476 times more likely to have better performance in the number of academic paper drafts compared to those with early-career tutors.

With the analysis of the academic publications as first or co-first authors, it was observed that several factors significantly influenced the outcome, including the feedback quality of tutors, the tutoring style and the tutor's career experience (Table 5). The feedback quality of tutors emerged as a positive impact factor (OR = 3.556, 95% CI 0.342–2.196, $p = 0.007$). That is, every one point increased in the feedback quality score of tutors was associated with a 3.556 times higher likelihood of publishing more papers. Furthermore, students mentored by authoritative tutors demonstrated a higher tendency in publications compared to those mentored by neglectful tutors, with an OR value of 12.829 (OR = 12.829, 95% CI 0.107–4.996, $p = 0.041$). Additionally, the OR of middle-career tutors compared to early-career tutors was 10.371 (OR = 10.371, 95% CI 0.749–3.929, $p = 0.004$), indicating that undergraduates mentored by middle-career tutors were ten times more likely to publish academic achievements than those mentored by early-career tutors.

As for the funded research projects, it was found to be influenced by the feedback quality between tutors and undergraduates and the tutor's career experience according to the findings of ordinal logistic regression (Table 6). Improvements in the quality of tutor-student feedback were found to effectively increase the number of projects, respectively (OR = 2.917, 95% CI 0.528–1.613, $P<0.001$ and OR = 1.902, 95% CI 0.018–1.268, $p = 0.044$). Taking the tutor with neglectful style for reference, the authoritative tutors were 5.244 times more likely to improve students' performance in funded research projects by at least one level (OR = 5.244, 95% CI 0.300–3.014, $p = 0.017$).

Discussion

UDBRE represents an innovative approach to enhancing research experiences within undergraduate education, and this study reaffirms its effectiveness. What sets this initiative apart from many others is the requirement for students to complete a compulsory course, thereby ensuring that research experiences are accessible to a broader spectrum of undergraduates, regardless of their prior knowledge of research methodologies. Recognizing the potential constraints related to time and resources that may impede the scalability of UDBRE, we explore strategies for improving guidance, with a primary focus on the pivotal role of feedback, tutoring style, and the experience of mentors.

In the student-centered model of UDBRE, the primary role of mentors is to facilitate the learning process, encourage collaboration, and provide formative feedback rather than impart factual knowledge (25). Teaching with feedback appears to be a promising solution based on the challenges posed by the lack of mentorship, where only 48.21% tutors provided more than 15-min mentorship per week, and each tutor was responsible for multiple grades of students. High-quality feedback between tutors and students is considered to be the students' motivation to continuous implementation of research

TABLE 3 Correlation between tutor-undergraduate feedback quality and undergraduates' scientific research abilities.

	Students' feedback quality	Tutors' feedback quality	Scientific questions developing	Scientific research projects design	Literature retrieving and reading	Academic writing	Experimental operation
Tutors' feedback quality	0.689**						
Scientific questions developing	0.615**	0.598**					
Scientific research projects design	0.652**	0.660**	0.788**				
Literature retrieving and reading	0.602**	0.577**	0.719**	0.780**			
Academic writing	0.646**	0.636**	0.755**	0.829**	0.845**		
Experimental operation	0.543**	0.522**	0.587**	0.649**	0.570**	0.597**	
Experimental results analyzing and evaluating	0.591**	0.573**	0.659**	0.729**	0.674**	0.712**	0.769**

Correlations were expressed as Kendall Tau-b coefficients ($\mathscr{T}$b). **$p < 0.01$.

TABLE 4 Multivariate logistic regression analysis of influential factors of completed academic draft for publication.

Explaining variable	B	S.E	Wald	*p*-value	OR	95% CI	
						Lower limit	Upper limit
Feedback quality of tutors	0.641	0.301	4.521	**0.033***	1.898	0.050	1.232
Feedback quality of undergraduates	0.674	0.341	3.901	**0.048***	1.963	0.005	1.343
Tutoring style							
Authoritative style = 1	1.937	0.800	5.858	**0.016***	6.938	0.368	3.506
Authoritarian style = 2	1.148	1.149	0.999	0.317	3.153	−1.103	3.400
Permissive style = 3	−0.712	0.903	0.622	0.430	0.491	−2.481	1.058
Neglectful style = 4	Reference category						
Career experience							
Late career = 1	−0.350	0.810	0.186	0.666	0.705	−1.937	1.237
Middle career = 2	1.700	0.634	7.203	**0.007****	5.476	0.459	2.942
Early career = 3	Reference category						
Dependent variable							
Completed research draft							
None =1	−2.651	1.271	4.349				
One = 2	7.002	1.427	24.08				
Two or more = 3							

Test of parallel lines: $p = 0.986$, pseudo $R^2 = 0.598$, Variance Inflation Factor (VIF) = 3.776. Results were adjusted for grade. Values in bold showed the statistically significant difference.
*$p < 0.05$, **$p < 0.01$. S.E: standard error; OR: odds ratio; CI: confidence interval.

project, and to promote students' progress in scientific research (26). When learners have a clear understanding of what they are being assessed on and regularly receive explicit feedback from others regarding their progress and abilities, they are more likely to provide more effective responses (27). Our study found that high-quality feedback of tutors and students had a significant positive effect on

TABLE 5 Multivariate logistic regression analysis of influential factors of published academic achievement.

Explaining variable	B	S.E	Wald	*p*-value	OR	95% CI	
						Lower limit	Upper limit
Feedback quality of tutors	1.269	0.473	7.196	**0.007****	3.556	0.342	2.196
Feedback quality of undergraduates	−0.389	0.436	0.797	0.372	0.678	−1.243	0.465
Tutor's style							
Authoritative style = 1	2.552	1.247	4.185	**0.041***	12.829	0.107	4.996
Authoritarian style = 2	1.822	1.663	1.200	0.273	6.185	−1.438	5.082
Permissive style = 3	−1.160	1.668	0.483	0.487	0.314	−4.429	2.110
Neglectful style = 4	Reference category						
Career experience							
Late career = 1	0.701	1.177	0.355	0.552	2.015	−1.606	3.008
Middle career = 2	2.339	0.811	8.317	**0.004****	10.371	0.749	3.929
Early career = 3	Reference category						
Dependent variable							
Published academic achievement							
None =1	6.895	2.020	11.657				
One = 2	10.582	2.194	23.266				
Two or more = 3							

Test of parallel lines: $p = 0.995$, pseudo $R^2 = 0.520$, VIF = 3.776. Results were adjusted for grade. Values in bold showed the statistically significant difference. *$p < 0.05$, **$p < 0.01$. S.E: standard error; OR: odds ratio; CI: confidence interval.

TABLE 6 Multivariate logistic regression analysis of influential factors of funded research projects.

Explaining variable	B	S.E	Wald	*p*-value	OR	95% CI	
						Lower limit	Upper limit
Feedback quality of tutors	1.070	0.277	14.939	**<0.001*****	2.917	0.528	1.613
Feedback quality of undergraduates	0.643	0.319	4.068	**0.044***	1.902	0.018	1.268
Tutor's style							
Authoritative style = 1	1.657	0.692	5.729	**0.017***	5.244	0.300	3.014
Authoritarian style = 2	0.219	0.967	0.051	0.821	1.245	−1.677	2.115
Permissive style = 3	−0.698	0.772	0.816	0.366	0.498	−2.211	0.816
Neglectful style = 4	Reference Category						
Career experience							
Late career = 1	−0.516	0.723	0.509	0.475	0.597	−1.932	0.901
Middle career = 2	−0.344	0.638	0.291	0.590	0.709	−1.595	0.907
Early career = 3	Reference Category						
Dependent variable							
Published academic achievement							
None =1	5.890	1.216	23.469				
One = 2	7.401	1.298	32.516				
Two or more = 3							

Test of parallel lines: $p = 0.683$, pseudo $R^2 = 0.625$, VIF = 3.776. Results were adjusted for grade. Values in bold showed the statistically significant difference. *$p < 0.05$, ***$p < 0.001$. S.E: standard error; OR: odds ratio; CI: confidence interval.

their own academic achievements, emphasizing the importance of appropriate feedback. Of note, compared with other abilities, the correlation between feedback quality and the improvement in experimental operation was weaker. This was possibly due to the outbreak of COVID-19, which resulted in students' inaccessibility to laboratories, and therefore they had no opportunities for experimental training (28). While the training of other skills could be carried out online without disruption. According to the open-ended responses, students hoped to obtain more opportunities to experience and learn more diversified experiments which required us to explore a more reasonable laboratory training system.

Appropriate teaching styles facilitate the establishment of an effective teaching atmosphere, improve the quality of feedback between tutors and undergraduate students, and finally promote academic progress (29). Previous studies have already demonstrated that the authoritative style is the most beneficial for students, and our study confirmed the similar effects of this tutoring style in scientific research (30). This superior performance might be attributed to the higher levels of academic effort and generally positive emotions exhibited by students under authoritative mentorship, who engage more robustly in academic activities on emotional, cognitive, and behavioral levels (31, 32). This primarily includes the enhancement of self-efficacy and motivation, which is positively associated with scientific identity and can be linked to the retention in scientific majors (33). While students of permissive and authoritative teachers experience the same level of positive emotions, the lower level of demand of permissive tutors leads to a decreased academic effort among students (34). Conversely, the authoritarian style, often perceived as excessively strict, may undermine students' motivation and autonomy, consequently resulting in sub-optimal teaching effectiveness (30).

The results indicated that the students of middle-career tutors performed better in terms of academic results compared to those of tutors with early careers. Tutors in the relatively early stages of their careers may have limited expertise and educational skills in the scientific domain (35). Consequently, undergraduates may not receive sufficient guidance or domain-specific knowledge to maximize their scientific and learning outcomes. However, although students could benefit from the higher-level research skills and abilities of late-career tutors, they did not have a better academic performance than students of mid-career teachers. This could be senior tutors have to undertake heavier tasks in clinical work, scientific research, administration, and teaching, etc., making it difficult to provide timely and effective guidance to help students solve problems (36). Similarly, research has found that more experienced teachers have a poorer interest in mentoring student research, which could also be a reason for their students' poorer academic performance (37). Therefore, tutors with middle-career experience, who possess both experience and energy, may be a better choice for tutoring students.

In summary, this study establishes a meaningful connection between the key design elements of UDBRE and both short-term and long-term student outcomes, providing empirical support for the potential of UDBRE to foster student growth within a model-based framework. However, it is important to acknowledge several limitations inherent to this study. First, the research was conducted exclusively within a single medical school in China, which may limit the generalizability of our findings. Thus, further validation in a larger and more diverse population is essential to strengthen the external validity of our conclusions. Second, this study adopted a cross-sectional design, which provides insights into the current impact of UDBRE. To comprehensively assess the enduring effects, a longitudinal cohort study tracking students over time would be a valuable addition to the research. Finally, it is important to recognize that students' motivation plays a critical role in influencing the outcomes and quality of UDBRE, as the selection process involves mutual agreement between tutors and students. While the full participation and uniform academic requirements of UDBRE can mitigate self-selection bias to some extent, future research should delve into variables related to academic motivation and preparedness. This would contribute to a more comprehensive understanding of the impact of UDBRE participation itself.

Conclusion

This study provides insights into the efficacious mentorship in UDBRE on scientific research of medical undergraduates in China. The results demonstrated that UDBRE engagement positively impacts students' performance in scientific research including their mastery of scientific research abilities and attributions in scientific research projects and academic outputs. Furthermore, high-quality of feedback, the authoritative tutoring style and the tutor with a middle-career experience had a positive predictive effect on students' academic performance. These findings offer useful suggestions and strategies to enhance the training effectiveness of UDBRE. They may also provide guidance for the future design and implementation of UDBRE programs.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors.

Ethics statement

The studies involving human participants were reviewed and approved by the Institutional Ethics Committee of Guangzhou Medical University. Written informed consent to participate in this study was provided by the participants.

Author contributions

XM: Data curation, Investigation, Writing – original draft. XC: Conceptualization, Investigation, Writing – review & editing. JL: Data curation, Investigation, Writing – original draft. ZW: Writing – review & editing. LG: Funding acquisition, Writing – review & editing, Methodology, Project administration. SL: Writing – review & editing,

Conceptualization, Supervision, Validation. TL: Supervision, Writing – review & editing, Funding acquisition.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This work was partially supported by the funding from Digital Precise Treatment of Oral Occlusal Reconstruction Related Diseases Program through the Affiliated Stomatology Hospital of Guangzhou Medical University (2023C-ZD07), the National Key Research and Development Program of China (2021YFE0108000), and grant from Guangzhou Medical University (S202210570043 and 02-408-2304). The study sponsors were not involved in the study design, implement, writing or submitting the manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

1. Mass-Hernández LM, Acevedo-Aguilar LM, Lozada-Martínez ID, Osorio-Agudelo LS, Maya-Betancourth JGEM, Paz-Echeverry OA, et al. Undergraduate research in medicine: a summary of the evidence on problems, solutions and outcomes. *Ann Med Surg*. (2022) 74:103280. doi: 10.1016/j.amsu.2022.103280

2. Gies WJ. *Dental education in the United States and Canada: A report to the Carnegie Foundation for the Advancement of Teaching*, vol. *20* Carnegie Foundation for the Advancement of Teaching (1926). 746 p.

3. Murdoch-Eaton D, Ellershaw J, Garden A, Newble D, Perry M, Robinson L, et al. Student-selected components in the undergraduate medical curriculum: a multi-institutional consensus on purpose. *Med Teach*. (2004) 26:33–8. doi: 10.1080/0142159032000150494

4. Holman SD, Wietecha MS, Gullard A, JMB P. U.S. dental students' attitudes toward research and science: impact of research experience. *J Dent Educ*. (2014) 78:334–48. doi: 10.1002/j.0022-0337.2014.78.3.tb05684.x

5. Scott JE, de Vries J, Iacopino AM. 25-year analysis of a dental undergraduate research training program (BSc dent) at the University of Manitoba Faculty of dentistry. *J Dent Res*. (2008) 87:1085–8. doi: 10.1177/154405910808701209

6. Istrate EC, Slapar FJ, Mallarapu M, Stewart DCL, West KP. Dentists of tomorrow 2020: an analysis of the results of the 2020 ADEA survey of U.S. dental school seniors. *J Dent Educ*. (2021) 85:427–40. doi: 10.1002/jdd.12568

7. Stengel A, Stanke KM, McPherson MR, Drijber RA. Virtually engaging students through collaborative investigation of scientific literature, a case study. *Nat Sci Educ*. (2021) 50:e20051. doi: 10.1002/nse2.20051

8. Chang Y, Ramnanan CJ. A review of literature on medical students and scholarly research: experiences, attitudes, and outcomes. *Acad Med*. (2015) 90:1162–73. doi: 10.1097/ACM.0000000000000702

9. Liu H, Gong Z, Ye C, Gan X, Chen S, Li L, et al. The picture of undergraduate dental basic research education: a scoping review. *BMC Med Educ*. (2022) 22:569. doi: 10.1186/s12909-022-03628-9

10. Yu W, Sun Y, Miao M, Li L, Zhang Y, Zhang L, et al. Eleven-year experience implementing a dental undergraduate research programme in a prestigious dental school in China: lessons learned and future prospects. *Eur J Dent Educ*. (2021) 25:246–60. doi: 10.1111/eje.12598

11. Elliott MK. Are we going in the right direction? A survey of the undergraduate medical education in Canada, Australia and the United Kingdom from a general practice perspective. *Med Teach*. (1999) 21:53–60. doi: 10.1080/01421599980048

12. Dolan EL, Johnson D. The undergraduate–postgraduate–faculty triad: unique functions and tensions associated with undergraduate research experiences at research universities. CBE—life sciences. *Education*. (2010) 9:543–53. doi: 10.1187/cbe.10-03-0052

13. Lyles JK, Oli M. The student-centered classroom: the new gut feeling. *FEMS Microbiol Lett*. (2020) 367:fnaa191. doi: 10.1093/femsle/fnaa191

14. Bopegedera AMRP. Student-driven, curriculum-embedded undergraduate research experiences (SD-CUREs) in the senior chemistry curriculum and its impact on students. *J Chem Educ*. (2021) 98:2549–58. doi: 10.1021/acs.jchemed.0c01140

15. Scott PH, Mortimer EF, Aguiar OG. The tension between authoritative and dialogic discourse: a fundamental characteristic of meaning making interactions in high school science lessons. *Sci Ed*. (2006) 90:605–31. doi: 10.1002/sce.20131

16. Linn MC, Palmer E, Baranger A, Gerard E, Stone E. Undergraduate research experiences: impacts and opportunities. *Science*. (2015) 347:1261757. doi: 10.1126/science.1261757

17. Chen H, Han J, Wright D. An investigation of lecturers' teaching through English medium of instruction—a case of higher education in China. *Sustainability*. (2020) 12:4046. doi: 10.3390/su12104046

18. Jansen T, Meyer J, Wigfield A, Möller J. Which student and instructional variables are most strongly related to academic motivation in K-12 education? A systematic review of meta-analyses. *Psychol Bull*. (2022) 148:1–26. doi: 10.1037/bul0000354

19. Tang Y, Hu J. The impact of teacher attitude and teaching approaches on student demotivation: disappointment as a mediator. *Front Psychol*. (2022) 13:985859. doi: 10.3389/fpsyg.2022.985859

20. Eagan MK, Sharkness J, Hurtado S, Mosqueda CM, Chang MJ. Engaging undergraduates in science research: not just about faculty willingness. *Res High Educ*. (2011) 52:151–77. doi: 10.1007/s11162-010-9189-9

21. Barni D, Russo C, Danioni F. Teachers' values as predictors of classroom management styles: a relative weight analysis. *Front Psychol*. (2018) 9:1970. doi: 10.3389/fpsyg.2018.01970

22. Rust C, Price M, O'Donovan B. Improving students' learning by developing their understanding of assessment criteria and processes. *Assess Eval High Educ*. (2003) 28:147–64. doi: 10.1080/02602930301671

23. Kaiser HF. An index of factorial simplicity. *Psychometrika*. (1974) 39:31–36. doi: 10.1007/BF02291575

24. Tabachnick BG, Fidell LS. *Using multivariate statistics*. 5. ed., Pearson internat. ed., [Nachdr.], vol. *20*. Boston, Mass. Munich: Pearson Allyn and Bacon.

25. Light C, Fegley M, Stamp N. Role of research educator in sequential course-based undergraduate research experience program. *FEMS Microbiol Lett*. (2019) 366:fnz140. doi: 10.1093/femsle/fnz140

26. Lee HJ, Kang YJ, Lee S-H, Lin Y, Kim D-H, Ihm J. Relationship matters: a qualitative study of medical students' experiences in a learner-driven research program in South Korea. *BMC Med Educ*. (2023) 23:337. doi: 10.1186/s12909-023-04337-7

27. Kardash CM. Evaluation of undergraduate research experience: perceptions of undergraduate interns and their faculty mentors. *J Educ Psychol*. (2000) 92:191–201. doi: 10.1037/0022-0663.92.1.191

28. Elmer SJ, Durocher JJ. Moving student research forward during the COVID-19 pandemic. *Adv Physiol Educ*. (2020) 44:741–3. doi: 10.1152/advan.00153.2020

29. Liu F, Qu S, Fan Y, Chen F, He B. Scientific creativity and innovation ability and its determinants among medical postgraduate students in Fujian province of China: a cross sectional study. *BMC Med Educ*. (2023) 23:444. doi: 10.1186/s12909-023-04408-9

30. Skinner E, Belmont M. Motivation in the classroom: reciprocal effect of teacher behavior and student engagement across the school year. *J Educ Psychol*. (1993) 85:571–81. doi: 10.1037/0022-0663.85.4.571

31. Fredricks JA, Blumenfeld PC, Paris AH. School engagement: potential of the concept, state of the evidence. *Rev Educ Res*. (2004) 74:59–109. doi: 10.3102/00346543074001059

32. Reeve J, Jang H, Carrell D, Jeon S, Barch J. Enhancing students' engagement by increasing teachers' autonomy support. *Motiv Emot*. (2004) 28:147–69. doi: 10.1023/B:MOEM.0000032312.95499.6f

33. Robnett RD, Chemers MM, Zurbriggen EL. Longitudinal associations among undergraduates' research experience, self-efficacy, and identity: research experience, self-efficacy and identity. *J Res Sci Teach*. (2015) 52:847–67. doi: 10.1002/tea.21221

34. Thijs J, Verkuyten M. Students' anticipated situational engagement: the roles of teacher behavior, personal engagement, and gender. *J Genet Psychol*. (2009) 170:268–86. doi: 10.1080/00221320903218323

35. Auchincloss LC, Laursen SL, Branchaw JL, Eagan K, Graham M, Hanauer DI, et al. Assessment of course-based undergraduate research experiences: a meeting report. CBE—life sciences. *Education*. (2014) 13:29–40. doi: 10.1187/cbe.14-01-0004

36. Chen S, Pan Y, Yao Q, Yao L, Liu Z, Xiang L. Publication pressure on Chinese doctors—another view. *Lancet*. (2014) 384:956. doi: 10.1016/S0140-6736(14)61630-5

37. Partido BB, Chartier EA, Heminger B. Experiences and attitudes of dental hygiene faculty regarding the mentorship of undergraduate student research. *J Dent Educ*. (2020) 84:1202–9. doi: 10.1002/jdd.12290

frontiers | Frontiers in Medicine

TYPE Case Report
PUBLISHED 15 January 2024
DOI 10.3389/fmed.2024.1335043

OPEN ACCESS

EDITED BY
Angelo Leone,
University of Palermo, Italy

REVIEWED BY
Ana Corte-Real,
University of Coimbra, Portugal
Georges Aoun,
Lebanese University, Lebanon

*CORRESPONDENCE
Yanmin Zhou
✉ zhouym@jlu.edu.cn

RECEIVED 08 November 2023
ACCEPTED 02 January 2024
PUBLISHED 15 January 2024

CITATION
Liu X, Lv H, Chen M, Chen S, Jia K, Quni S, Zhang L and Zhou Y (2024) Case report and literature review: autonomous robotic system assisted palatal implantation at an anterior teeth site compromised by periapical cyst. *Front. Med.* 11:1335043.
doi: 10.3389/fmed.2024.1335043

Case report and literature review: autonomous robotic system assisted palatal implantation at an anterior teeth site compromised by periapical cyst

Xiuyu Liu[1], Huixin Lv[1], Meiqing Chen[2], Siyu Chen[1], Kewen Jia[1], Sezhen Quni[1], Lu Zhang[1] and Yanmin Zhou[1]*

[1]Hospital of Stomatogy, Jilin University, Changchun, China, [2]Department of Stomatology, China-Japan Union Hospital of Jilin University, Changchun, China

Background: Immediate implant placement (IIP), which preserves gingival height and papilla shape while simultaneously accelerating the implant treatment period, has become a popular method due to its commendable clinical outcomes. Nonetheless, deploying immediate implants demands specific preconditions concerning the remaining alveolar bone. This poses a challenge to the accuracy of implant surgery.

Case presentation: In this report, we present the case of a 60-year-old woman with a left upper anterior tooth crown dislodged for over a month. Cone beam computed tomography (CBCT) revealed the absence of a labial bone wall on tooth 22, a remaining 1 mm bone wall on the labial side of the root apex, and a 17.2 mm*8.9 mm*4.7 mm shadow in the periapical region of the root apices of teeth 21 and 22, with the narrowest width on the sagittal plane being approximately 5 mm. After the surgeon removed the cyst, they completed the subsequent implantation surgery using an autonomous robot in a challenging aesthetic area. This method circumvented the potential exposure of the screw thread on the labial implant surface, assured initial implant stability.

Conclusion: Five months after the operation, the dental crown was restored. The implant remained stable, with yielding notable clinical results. To the best of our knowledge, this clinical case is the first to report the feasibility and precision of immediate implantation in anterior teeth site with periapical cyst removal, performed by an autonomous robotic surgical system. Autonomous robots exhibit exceptional accuracy by accurately controlling axial and angular errors. It can improve the accuracy of implant surgery, which may become a key technology for changing implant surgery. However, further clinical trials are still needed to provide a basis for the rapid development of robotic surgery field.

KEYWORDS

immediate implant, aesthetic area, dynamic navigation, static navigation, case report

1 Introduction

The development of medical technology and biocompatibility materials has provided a variety of treatments for tooth defects caused by caries, trauma and tumors, but due to aesthetic requirements, leading to restoration of the anterior teeth remains a challenge. Immediate Implant Placement (IIP), which preserves gingival height and papilla shape while simultaneously accelerating the implant treatment period, has become a popular method due to its commendable clinical outcomes (1). A salient advantage of IIP is its ability to eliminate the bone healing stage post tooth extraction, thereby significantly abbreviating the implant treatment duration (2). Moreover, this approach facilitates the preservation of the soft tissue structure, culminating in superior aesthetic results (3).

Nonetheless, deploying immediate implants in aesthetic areas demands specific preconditions concerning the remaining alveolar bone. These include: a labial bone wall of at least 1 mm thickness; a thick gingival biotype; the absence of acute inflammation within the alveolar fossa; and sufficient bone mass in the root of alveolar fossa and palatal side to guarantee the initial stability of implant in its accurate three-dimensional position (4). As these teeth are primarily extracted due to acute or chronic inflammation, inflammation-induced bone defects can impede the initial stability of implant or result in thread exposure, thus complicating implant precision (5).

For the assurance of initial implant stability and long-term survival, maximal utilization of the remaining alveolar ridge is essential. When the buccal alveolar ridge is insufficient, palatal implant placement is proposed. This creates a 2 mm gap on the buccal side, and an augmentation osteotomy is performed to ensure the longevity of the implants (6, 7). Critical factors for a successful procedure include precise planning of the ideal implant position and accurate transfer of this planned position to the surgical site. Because free-hand manipulation is affected by many factors, including doctor's experience, environment and patient's cooperation, some scholars consider using guide plate to reduce human error. With the development of Science and Technology, robotic surgery has attracted much attention because of its high accuracy. (8, 9). The autonomous robotic system, pioneered by Professor Zhao, executes implant insertion as per preoperative design, with surgeons intervening when necessary (10). With the high accuracy of robot, the implant can be precisely placed at the preoperative design site in a critical bone defect while simultaneously avoiding implant thread exposure. To the best of our knowledge, this clinical case is the first to report the feasibility and precision of immediate implantation in an aesthetic area with periapical cyst removal, performed by an autonomous robotic surgical system, followed by a literature review.

2 Case presentation

The patient is a 60-year-old woman presenting with a left upper anterior tooth crown dislodged for over a month. The chief complaint suggested that an injury to her left upper anterior tooth a month prior, causing the original restoration to dislodge. Her dental history revealed a crown restoration on the upper anterior tooth a decade ago. Upon clinical examination, the following observations were made: a residual crown on tooth 22, normal gingival color and texture without redness, a thin gingival type of lip gingiva, a median laughing line, and a normal jaw position relationship. Tooth 21 had a post and a core crown (Figure 1A). Cone beam computed tomography (CBCT) revealed the absence of a labial bone wall on tooth 22, a remaining 1 mm bone wall on the labial side of the root apex, and a 17.2 mm*8.9 mm*4.7 mm shadow in the periapical region of the root apices of teeth 21 and 22, with the narrowest width on the sagittal plane being approximately 5 mm (Figure 2A). The diagnosis comprised a residual crown on tooth 22 and periapical cysts on teeth 21 and 22. The preoperative aesthetic risk assessment was moderate to low, despite the presence of apical labial bone defects and high aesthetic risk factors associated with adjacent teeth with prostheses (11).

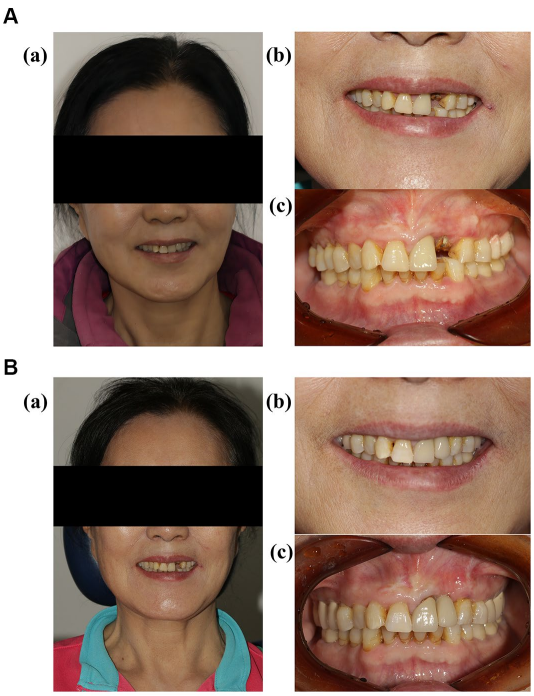

FIGURE 1
(A) (a) Frontal images of the patient before the operation; (b,c) intraoral images of the patient before the operation. **(B)** (a) Frontal images of the patient 5 months after the permanent restoration; (b,c) intraoral images of the patient 5 months after the permanent restoration.

A CBCT scan was conducted on the day of the patient arrived. The results and the virtual plan was then digitally transmitted to the robot (YaKeBot, DRS0605-FT250). The oral cavity of patient was scanned, and a three dimensional (3D) printer was used to create a positioning guide (Figures 2B,C).

Before proceeding, a comprehensive treatment plan was presented to the patient, and written informed consent was obtained for the implantation procedure. Following local infiltration anesthesia, the tooth was extracted. Subsequent to the removal of the periapical cyst tissue via a flap technique, inflammatory soft tissue was meticulously cleared away. A temporary positioning guide plate was affixed to the maxillary dentition of patient for movement monitoring. Once the robotic tracking arm was calibrated, the surgeon, acting as the operator, released the robot arm, moving it to the surgical site for implant placement. A single implant (Straumann Bone Level Tapered Roxolid SLA, 3.3 mm*12 mm) was inserted intraoperatively with a

torsional force of approximately 35 N cm, achieving satisfactory initial stability. Subsequent to the placement of bone powder in the labial bone defect, collagen and RPF membranes (Bio-Gide 13 mm*25 mm; Bio-Oss, 0.25 g, Switzerland) were placed, and a tension-free suture closed the wound (Figure 3). A CBCT scan was carried out immediately post-surgery to examine the implant placement. The entire procedure lasted for a total of 70 min. The calibration of the machine required 10 min, while the implantation executed by the robot took 20 min. The patient experienced no notable discomfort or adverse reactions. Implant discrepancies were evaluated by comparing the pre-designed STL files with the immediate post-operative CBCT (Figures 4C,D).

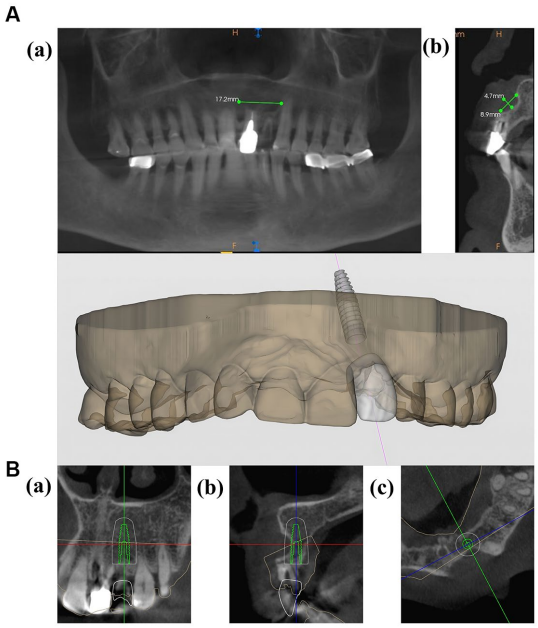

FIGURE 2
(A) (a,b) CBCT images of the patient before the operation. **(B,C)** Preoperative planning for implant placement.

CBCT indicated that 22 labial bone plates exhibited satisfactory fullness, thereby assuring the function and aesthetic appeal of both soft and hard tissues in the implant area. Changes in the soft and hard tissues before the operation and after the operation were compared (Figures 4A,B). Resonance frequency analysis (PFA) was used to measure the stability of implants. PFA reflects the stiffness of bone-implant interface by implant stability quotient (ISQ) value. The (ISQ) was above 65, fulfilling the restoration standard (12). The final crown restoration was then completed by digitizing the casts (Figure 1B). The gingival color, shape, and texture recovered well, and the alveolar bone contours were full within 5 months post-implantation. The Pink Esthetics Score (PES) stood at 10 (13). CBCT and STL data were imported into Mimics Medical 21.0 and Geomagic Design X. This software was employed to calculate the bone volume increase to 455.4 cubic millimeters, while the soft tissue regression was measured at 1.94 mm.

3 Discussion

Immediate implantation condenses the treatment cycle and preserves existing soft and hard tissue, contributing to an enhanced aesthetic effect (14, 15). In our case, the labial bone of patient wall was missing due to a periapical cyst. According to the prevailing standard for immediate implantation, this condition is unsuitable for immediate implantation, and delayed implantation should be considered after the bone has healed. However, in our case, a robot-assisted palatal intraosseous implant was employed immediately following cyst removal. What's even more remarkable, the clinical results demonstrate that the robotic surgery system efficiently utilizes the

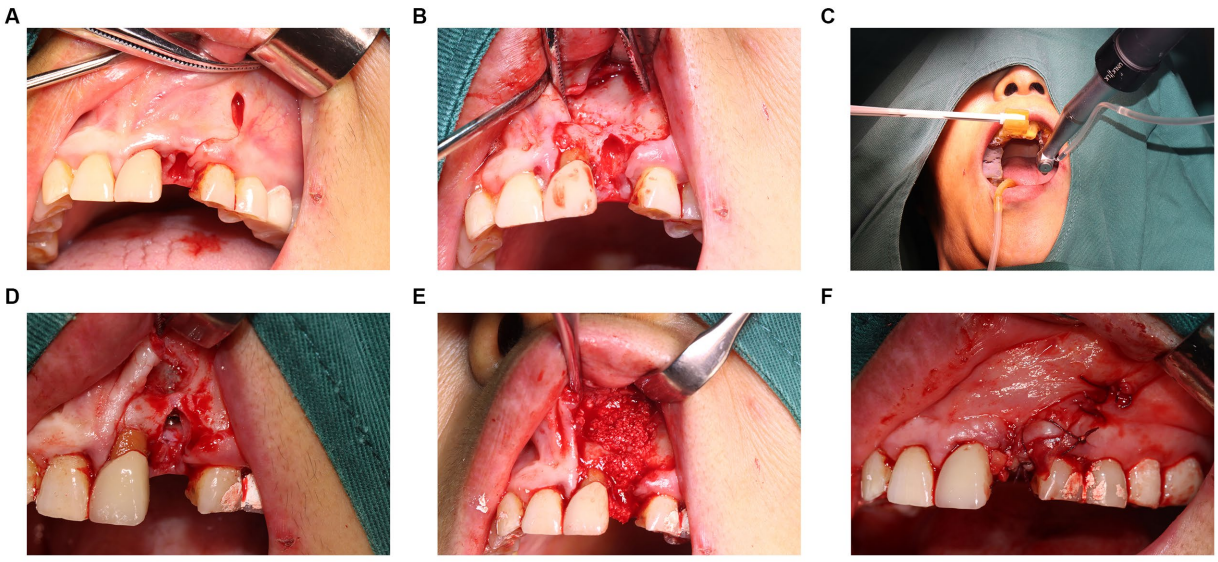

FIGURE 3
Intraoperative images. **(A,B)** Removal of cyst tissue and affected teeth. **(C)** The robot performs drilling and implant placement based on a pre designed path. **(D)** The implant has been placed in the alveolar bone. **(E)** Placement of bone powder to fill bone defects. **(F)** Tightly sutured wound.

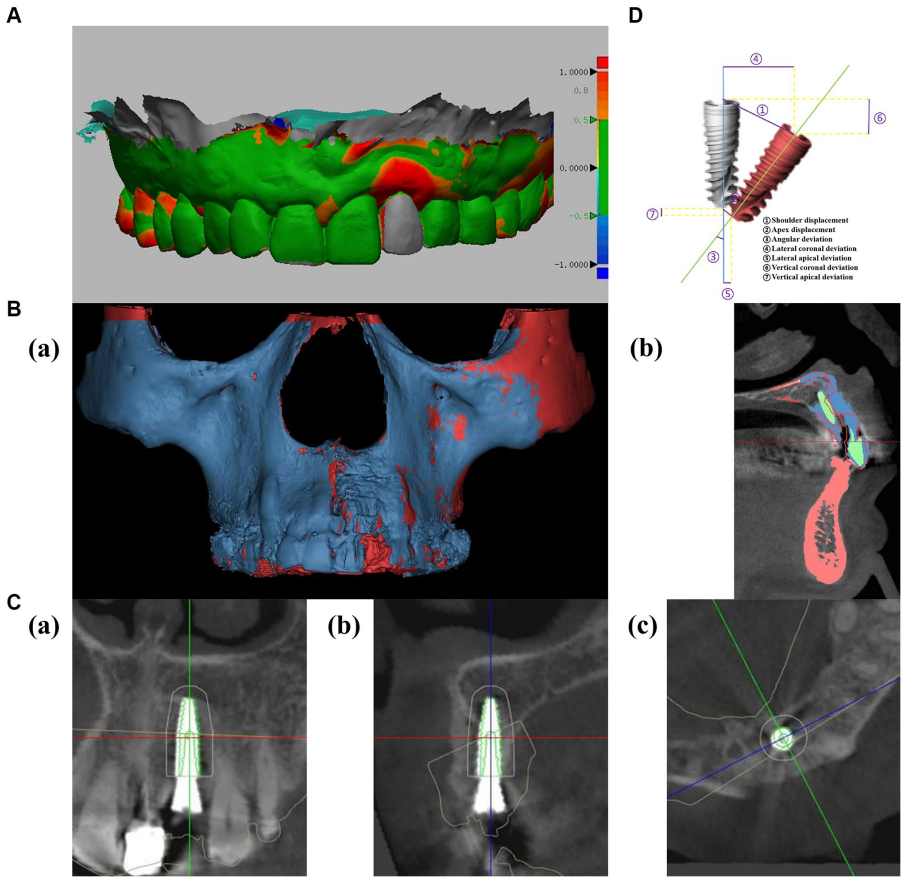

FIGURE 4
(A) Analysis of soft tissue recession using oral scanning data (soft tissue volumes were compared by comparing pre-and post-operative oral scan data, and color represented differences in gingival changes, which could be defined by the right scale). **(B)** Analysis of bone volume changes using CBCT (red represents preoperative bone tissue, blue represents postoperative bone tissue, and green represents implants and restorations). **(C)** Postoperative evaluation: comparing accuracy of preoperative planned implant position (green) with postoperative position. **(D)** Deviations of planned (gray) and actual position (red) of implant.

residual alveolar bone of patient, achieving substantial initial stability without exposing the implant surface. CBCT captured immediately after the operation revealed an error of about 0.4 mm between the implant site and the preoperative design. The crowns were restored 5 months after surgery, the mean volume of soft tissue change measured was 1.94 mm.

A previous research indicates that the vertical height of the labial alveolar bone of the implant significantly impacts the aesthetic appearance of the soft tissue and is closely tied to the placement of implant (16). Additionally, many studies have found that a labial alveolar bone thickness of at least 2 mm around implants is a positive factor for long-term soft tissue stability (17, 18). If bone mass is insufficient, delayed implantation, while more likely to ensure long-term implant stability, can result in severe alveolar-level resorption and soft-tissue retraction post-extraction, adversely influencing aesthetic prosthetics (15). Edith Groendijk in a prospective study, proposed fully utilizing palatal alveolar bone to achieve a minimum 2 mm gap with a buccal alveolar ridge as an effective method for addressing labial bone defects in the anterior region (6). In this case, the cyst caused a labial alveolar bone defect, but according to the CBCT, the average width of the palatal bone wall was 5 mm and the height of the bone was 19 mm. This could not only assure the stability of implant but also minimize the absorption of the labial bone wall and maintain the height and width of the labial bone. Therefore, we opted for palatal alveolar bone to carry out the implant operation and selected an implant with a diameter of 3.3 mm and a length of 12 mm to ensure complete implantation into the bone.

The degree of soft tissue alteration post immediate implantation within the aesthetic zone is a critical determinant of aesthetic outcomes. A mean soft tissue shrinkage of 0.27 ± 0.38 mm was observed in the mid-facial region following a 1–5 years follow-up study (19). The regression measured in this study amounted to 1.94 mm. According to previous literature, the causes of soft tissue retraction in this case can be attributed to the following: Firstly, the labial alveolar bone of the afflicted tooth exhibits a UU type bone defect. The research of Mizuno K established a notable positive correlation between alveolar bone defect severity and gingival recession (20). Additionally, the utilization of periodontal probes revealed the gums of patient to be of a thin gingival biotype (21), a significant risk factor for post-implant surgery gingival recession (22). The study of Nurit Bittner recorded a higher incidence of gingival recession in the thin phenotype (1.96 mm) compared to the thick phenotype (1.18 mm) (23). Secondly, alveolar bone defects following the removal of a periapical cyst also contribute to gingival retraction

(24). Concomitantly, flap surgery is necessitated due to periapical cyst treatment and bone augmentation surgery, thereby escalating the risk of soft tissue retraction. The study of Filiep RaesLin compared the post-procedure outcomes of immediate implantation between flap surgery and flapless methods. Twenty-three patients underwent immediate implant placement while seven received conventional therapy. The immediate implant group exhibited a 43% reduction, compared to approximately 26% in the control group. Particularly, at the 40th week follow-up, the flapless technique demonstrated a significantly lesser decline than the flap method (25). Despite the use of robotic surgery, imperfect aesthetic outcomes were achieved, which was closely related to the aesthetic risk factors assessed preoperatively. This suggests that doctors should critically assess the risks and perform the surgery without compromising patient safety (26). In addition to surgical and anatomical factors, prostheses can also affect the shape of soft tissue. In fact, careful design is necessary because the shape, position, and color of the prosthesis can affect the shape and color of the soft tissue, which helps to simulate normal gingival contour. For patients with interdental papilla loss, the Oscar study suggests that an attempt to increase height can be made by changing the subcritical contour, which is closely related to soft tissue regeneration and plasticity (27).

In implant surgery, the three-dimensional positioning of the implant is critical for achieving long-term stability and optimal aesthetic results. Incorrect implant placement may induce marginal bone resorption and potentially infringe upon adjacent vital anatomical structures (28). In this case study, the autonomous robotic system employed optical sensors to ascertain the position relationship between the implant and the jaw, enabling accurate placement of the implant into the optimal location within the palatal bone. This took into account the depth and inclination, along with the biological, aesthetic, and functional considerations of the suprastructure, to support long-term aesthetic results and the health of peri-implant tissues. This system provides superior positioning accuracy compared to traditional navigation systems and can align the implant with the preoperative design. In this case, the deviation for shoulder displacement, apex displacement, and angular deviation were 0.42 mm, 0.42 mm, and 0.65°, respectively. These measurements indicate higher precision in comparison to reported errors from dynamic navigation (1.24 ± 0.39 mm, 1.58 ± 0.56 mm, 3.78° ± 1.84°), static navigation (0.87 ± 0.49 mm, 1.10 ± 0.53 mm, 2.41° ± 1.47°) and freehand methods (1.3 ± 0.7 mm, 2.2 ± 1.2 mm, 7.0° ± 7.0°) (29, 30). Current researches show that several factors affect the accuracy of digital navigation systems, including the precision of CBCT and oral scanning (or die removal), flap design, implant positioning, interference from cortical bone, stability of the guide plate, length of the drill bit and stem, compatibility between the guide rail and the drill bit, and the errors procedural of operator (31, 32). The accuracy of static navigation depends on the guide precision of plate. Factors that influence this include the cumulative errors from imaging examination, operation plan transfer, model construction, and guide plate fabrication. Moreover, the necessary sleeve tolerances (the space between the sleeve and the bit allowing for cooling water circulation and bit rotation) inherent in guide plate production can also impact the accuracy of implant procedures (33, 34). The research of Raico Gallardo suggests that tooth-supported guides demonstrate greater accuracy than mucosa-supported or bone-supported guides, possibly because tissue swelling from intraoperative local anesthesia can affect the positioning of guide plate (35). Dynamic navigation systems use sensors like cameras to locate the installed reference frame of patient and handheld device in real-time. These systems utilize CBCT data to calculate the relative spatial position between the patient and the drill bit, providing surgeons with real-time visual guidance during drilling (36). While dynamic navigation systems eliminate guide plate sleeve errors, they still require a guide plate system for location and calibration, tying their accuracy to guide plate manufacturing and placement. The accuracy of CBCT is crucial for scheme design and intraoperative guidance in dynamic navigation systems. Although CBCT delivers high accuracy in three-dimensional space, metal artifacts can affect image quality and precision (37). Akira Komuro indicated a discrepancy of 1.8–6.9% between CBCT measurements and actual values (38). Todorovic also noted that CBCT is not reliable for developing thin bone plates, which can impact the accuracy of dynamic navigation system (39). Robotic systems employ a real-time positioning system similar to dynamic navigation, which is also influenced by guide plate systems and CBCT errors. It is suggested that surgeons can minimize these errors by improving guide plate fabrication and placement precision, as well as CBCT accuracy. Notably, in addition to ensuring accuracy, the planting robot also uses mechanical sensors to prevent patient injury from the drill needle. The intraoperative robot can also adjust minor patient movements, ensuring accuracy and safety.

The autonomous robot not only demonstrated excellent accuracy, but also broke the technical sensitivity barrier of complex surgery. Immediate implantation in aesthetic areas is categorized as a type C operation, denoted as complex within the SAC classification [(S) simple, (A) advanced, (C) complex]. This is typically performed solely by implant surgeons with extensive experience, training, and education (4). Achieving complete bone wall coverage and initial implant stability can be challenging with free-hand immediate implantation. The application of robotic systems enables novice surgeons to independently perform complex procedures, fostering the growth of precision medicine technologies and significantly reducing the training period of surgeon. While static computer-assisted implant surgery (SCAIS) and dynamic computer-assisted implant surgery (DCAIS) provide higher accuracy than free-hand methods, they cannot entirely eliminate surgeon-related errors (40, 41). Neither static nor dynamic navigation can avoid direct intervention by the surgeon. Specifically, in dynamic navigation, the absence of a mechanical guidance device implies that the angle and position of drill and implant are entirely controlled by the surgeon (42). The study of Widmann suggests that a tremor and inaccurate hand perception could lead to an error of 0.25 mm and 0.5° (43). Few studies have analyzed the impact of clinical experience of a surgeon on the accuracy of static navigation. According to research by Van and Cassetta, implant placement errors in both experienced and inexperienced groups were primarily due to angular bias. Inaccurate placement of the guide plate was a significant factor contributing to implant inaccuracies (44). Dynamic navigation hinges on the hand-eye coordination of surgeon, which necessitates a learning period for proficiency in both navigation display data interpretation and implantation operations (45). However, the study of Gerardo Pellegrino posited that the accuracy of the dynamic navigation system was independent of the operator implant experience and familiarity with the dynamic navigation surgery, though noticeable differences were observed in drilling timing (46). The principal distinction

between an autonomous robotic system and static and dynamic navigation lies in the utilization of robotic arms for implant procedures, with the surgeon functioning as the pilot of robot. The use of a robotic arm for drilling and implant placement effectively reduces the errors arising from manual operation and further diminishes the impact of operational experience on implant procedures.

4 Conclusion

We report a case of immediate implantation using an autonomous implant robot in a severe bone defect. Under the premise of ensuring the safety, the autonomous robot places the implants into the alveolar bone. The robot avoids thread exposure of the implant surface and ensures the initial stability of the implant. To the best of our knowledge, this clinical case is the first to report the feasibility and precision of immediate implantation in anterior teeth site with periapical cyst removal, performed by an autonomous robotic surgical system. Autonomous robot systems have emerged as a potential solution to tooth defects and are expected to become a mainstream medical technology in the near future. However, additional clinical trials are needed to verify the reliability of the system.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

XL: Conceptualization, Investigation, Project administration, Software, Writing – original draft, Writing – review & editing. HL: Conceptualization, Data curation, Writing – review & editing. MC: Data curation, Investigation, Methodology, Software, Writing – review & editing. SC: Conceptualization, Data curation, Writing – review & editing. KJ: Data curation, Investigation, Methodology, Software, Writing – review & editing. SQ: Data curation, Investigation, Writing – review & editing. LZ: Data curation, Investigation, Writing – review & editing. YZ: Data curation, Funding acquisition, Investigation, Software, Writing – review & editing.

Funding

The author (s) declare financial support was received for the research, authorship, and/or publication of this article. This work was supported by National Natural Science Foundation of China: 82371006.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

1. Lee W. Immediate implant placement in fresh extraction sockets. *J Korean Assoc Oral Maxillofac Surg*. (2021) 47:57–61. doi: 10.5125/jkaoms.2021.47.1.57

2. Donker VJJ, Raghoebar GM, Vissink A, Meijer HJA. Digital workflow for immediate implant placement and chairside provisionalization in the esthetic zone. *Case Rep Dent*. (2022) 2022:5114332–9. doi: 10.1155/2022/5114332

3. Saijeva A, Juodzbalys G. Immediate implant placement in non-infected sockets versus infected sockets: a systematic review and Meta-analysis. *J Oral Maxillofac Res*. (2020) 11:e1. doi: 10.5037/jomr.2020.11201

4. Buser D, Chappuis V, Belser UC, Chen S. Implant placement post extraction in esthetic single tooth sites: when immediate, when early, when late? *Periodontol*. (2017) 73:84–102. doi: 10.1111/prd.12170

5. Kakar A, Kakar K, Leventis MD, Jain G. Immediate implant placement in infected sockets: a consecutive cohort study. *J Lasers Med Sci*. (2020) 11:167–73. doi: 10.34172/jlms.2020.28

6. Groenendijk E, Staas TA, Bronkhorst EM, Raghoebar GM, Meijer GJ. Factors associated with esthetic outcomes of flapless immediate placed and loaded implants in the maxillary incisor region-three-year results of a prospective case series. *J Clin Med*. (2023) 12:2625. doi: 10.3390/jcm12072625

7. Lei C, Yu Q, Wu D, Cai K, Weigl P, Tang C. Comparison of alveolar bone width and sagittal tooth angulation of maxillary central incisors in class I and class III canine relationships: a retrospective study using CBCT. *BMC Oral Health*. (2022) 22:303. doi: 10.1186/s12903-022-02331-x

8. Bi S, Wang M, Zou J, Gu Y, Zhai C, Gong M. Dental implant navigation system based on Trinocular stereo vision. *Sensors (Basel)*. (2022) 22:2571. doi: 10.3390/s22072571

9. Bolding SL, Reebye UN. Accuracy of haptic robotic guidance of dental implant surgery for completely edentulous arches. *J Prosthet Dent*. (2022) 128:639–47. doi: 10.1016/j.prosdent.2020.12.048

10. Tao B, Feng Y, Fan X, Zhuang M, Chen X, Wang F, et al. Accuracy of dental implant surgery using dynamic navigation and robotic systems: an in vitro study. *J Dent*. (2022) 123:104170. doi: 10.1016/j.jdent.2022.104170

11. Greenberg JR, Bogert MC. A dental esthetic checklist for treatment planning in esthetic dentistry. *Compend Contin Educ Dent*. (2010) 31:630–4.

12. Supachaiyakit P, Serichetaphongse P, Chengprapakorn W. The influence of implant design on implant stability in low-density bone under guided surgical template in inexperienced surgeons: a pilot randomized controlled clinical trial using resonance frequency analysis. *Clin Implant Dent Relat Res*. (2022) 24:444–54. doi: 10.1111/cid.13100

13. Furhauser R, Florescu D, Benesch T, Haas R, Mailath G, Watzek G. Evaluation of soft tissue around single-tooth implant crowns: the pink esthetic score. *Clin Oral Implants Res*. (2005) 16:639–44. doi: 10.1111/j.1600-0501.2005.01193.x

14. Meng HW, Chien EY, Chien HH. Immediate implant placement and provisionalization in the esthetic zone: a 6.5-year follow-up and literature review. *Case Rep Dent*. (2021) 2021:4290193. doi: 10.1155/2021/4290193

15. Puisys A, Deikuviene J, Vindasiute-Narbute E, Razukevicus D, Zvirblis T, Linkevicius T. Connective tissue graft vs porcine collagen matrix after immediate implant placement in esthetic area: a randomized clinical trial. *Clin Implant Dent Relat Res*. (2022) 24:141–50. doi: 10.1111/cid.13058

16. Grunder U, Gracis S, Capelli M. Influence of the 3-D bone-to-implant relationship on esthetics. *Int J Periodontics Restorative Dent*. (2005) 25:113–9.

17. Stefanini M, Sangiorgi M, Bianchelli D, Bellone P, Gelpi F, De Santis D, et al. A novel Muco-gingival approach for immediate implant placement to obtain soft-and hard-tissue augmentation. *J Clin Med*. (2022) 11. doi: 10.3390/jcm11174985

18. Levine RA, Dias DR, Wang P, Araujo MG. Effect of the buccal gap width following immediate implant placement on the buccal bone wall: a retrospective cone-beam computed tomography analysis. *Clin Implant Dent Relat Res*. (2022) 24:403–13. doi: 10.1111/cid.13095

19. Khzam N, Arora H, Kim P, Fisher A, Mattheos N, Ivanovski S. Systematic review of soft tissue alterations and esthetic outcomes following immediate implant placement and restoration of single implants in the anterior maxilla. *J Periodontol*. (2015) 86:1321–30. doi: 10.1902/jop.2015.150287

20. Mizuno K, Nakano T, Shimomoto T, Fujita Y, Ishigaki S. The efficacy of immediate implant placement in the anterior maxilla with dehiscence in the facial alveolar bone: a case series. *Clin Implant Dent Relat Res*. (2022) 24:72–82. doi: 10.1111/cid.13059

21. Kan JY, Rungcharassaeng K, Umezu K, Kois JC. Dimensions of peri-implant mucosa: an evaluation of maxillary anterior single implants in humans. *J Periodontol*. (2003) 74:557–62. doi: 10.1902/jop.2003.74.4.557

22. Ramanauskaite A, Sader R. Esthetic complications in implant dentistry. *Periodontol*. (2022) 88:73–85. doi: 10.1111/prd.12412

23. Bittner N, Schulze-Späte U, Silva C, Da Silva JD, Kim DM, Tarnow D, et al. Changes of the alveolar ridge dimension and gingival recession associated with implant position and tissue phenotype with immediate implant placement: a randomised controlled clinical trial. *Int J Oral Implantol*. (2019) 12:469–80.

24. Kan JYK, Rungcharassaeng K, Deflorian M, Weinstein T, Wang HL, Testori T. Immediate implant placement and provisionalization of maxillary anterior single implants. *Periodontol*. (2018) 77:197–212. doi: 10.1111/prd.12212

25. Raes F, Cosyn J, Crommelinck E, Coessens P, De Bruyn H. Immediate and conventional single implant treatment in the anterior maxilla: 1-year results of a case series on hard and soft tissue response and aesthetics. *J Clin Periodontol*. (2011) 38:385–94. doi: 10.1111/j.1600-051X.2010.01687.x

26. Corte-Real A, Caetano C, Alves S, Pereira AD, Rocha S, Nuno VD. Patient safety in dental practice: lessons to learn about the risks and limits of professional liability. *Int Dent J*. (2021) 71:378–83. doi: 10.1016/j.identj.2020.12.014

27. Gonzalez-Martin O, Lee E, Weisgold A, Veltri M, Su H. Contour Management of Implant Restorations for optimal emergence profiles: guidelines for immediate and delayed provisional restorations. *Int J Periodontics Restorative Dent*. (2020) 40:61–70. doi: 10.11607/prd.4422

28. Ramaglia L, Toti P, Sbordone C, Guidetti F, Martuscelli R, Sbordone L. Implant angulation: 2-year retrospective analysis on the influence of dental implant angle insertion on marginal bone resorption in maxillary and mandibular osseous onlay grafts. *Clin Oral Investig*. (2015) 19:769–79. doi: 10.1007/s00784-014-1275-5

29. Kiatkroekkrai P, Takolpuckdee C, Subbalekha K, Mattheos N, Pimkhaokham A. Accuracy of implant position when placed using static computer-assisted implant surgical guides manufactured with two different optical scanning techniques: a randomized clinical trial. *Int J Oral Maxillofac Surg*. (2020) 49:377–83. doi: 10.1016/j.ijom.2019.08.019

30. Yimarj P, Subbalekha K, Dhanesuan K, Siriwatana K, Mattheos N, Pimkhaokham A. Comparison of the accuracy of implant position for two-implants supported fixed dental prosthesis using static and dynamic computer-assisted implant surgery: a randomized controlled clinical trial. *Clin Implant Dent Relat Res*. (2020) 22:672–8. doi: 10.1111/cid.12949

31. Derksen W, Wismeijer D, Flugge T, Hassan B, Tahmaseb A. The accuracy of computer-guided implant surgery with tooth-supported, digitally designed drill guides based on CBCT and intraoral scanning. A prospective cohort study. *Clin Oral Implants Res*. (2019) 30:1005–15. doi: 10.1111/clr.13514

32. Kaewsiri D, Panmekiate S, Subbalekha K, Mattheos N, Pimkhaokham A. The accuracy of static vs. dynamic computer-assisted implant surgery in single tooth space: a randomized controlled trial. *Clin Oral Implants Res*. (2019) 30:505–14. doi: 10.1111/clr.13435

33. Younes F, Cosyn J, De Bruyckere T, Cleymaet R, Bouckaert E, Eghbali A. A randomized controlled study on the accuracy of free-handed, pilot-drill guided and fully guided implant surgery in partially edentulous patients. *J Clin Periodontol*. (2018) 45:721–32. doi: 10.1111/jcpe.12897

34. Chen CK, Yuh DY, Huang RY, Fu E, Tsai CF, Chiang CY. Accuracy of implant placement with a navigation system, a laboratory guide, and freehand drilling. *Int J Oral Maxillofac Implants*. (2018) 33:1213–8. doi: 10.11607/jomi.6585

35. Raico Gallardo YN, da Silva-Olivio IRT, Mukai E, Morimoto S, Sesma N, Cordaro L. Accuracy comparison of guided surgery for dental implants according to the tissue of support: a systematic review and meta-analysis. *Clin Oral Implants Res*. (2017) 28:602–12. doi: 10.1111/clr.12841

36. Bose MWH, Beuer F, Schwitalla A, Bruhnke M, Herklotz I. Dynamic navigation for dental implant placement in single-tooth gaps: a preclinical pilot investigation. *J Dent*. (2022) 125:104265. doi: 10.1016/j.jdent.2022.104265

37. Fontenele RC, Farias Gomes A, Nejaim Y, Freitas DQ. Do the tube current and metal artifact reduction influence the diagnosis of vertical root fracture in a tooth positioned in the vicinity of a zirconium implant? A CBCT study. *Clin Oral Investig*. (2021) 25:2229–35. doi: 10.1007/s00784-020-03538-4

38. Komuro A, Yamada Y, Uesugi S, Terashima H, Kimura M, Kishimoto H, et al. Accuracy and dimensional reproducibility by model scanning, intraoral scanning, and CBCT imaging for digital implant dentistry. *Int J Implant Dent*. (2021) 7:63. doi: 10.1186/s40729-021-00343-w

39. Todorovic VS, Postma TC, Hoffman J, van Zyl AW. Buccal and palatal alveolar bone dimensions in the anterior maxilla: a micro-CT study. *Clin Implant Dent Relat Res*. (2023) 25:261–70. doi: 10.1111/cid.13175

40. Pimkhaokham A, Jiaranuchart S, Kaboosaya B, Arunjaroensuk S, Subbalekha K, Mattheos N. Can computer-assisted implant surgery improve clinical outcomes and reduce the frequency and intensity of complications in implant dentistry? A critical review. *Periodontol*. (2022) 90:197–223. doi: 10.1111/prd.12458

41. Jaemsuwan S, Arunjaroensuk S, Kaboosaya B, Subbalekha K, Mattheos N, Pimkhaokham A. Comparison of the accuracy of implant position among freehand implant placement, static and dynamic computer-assisted implant surgery in fully edentulous patients: a non-randomized prospective study. *Int J Oral Maxillofac Surg*. (2023) 52:264–71. doi: 10.1016/j.ijom.2022.05.009

42. Tahmaseb A, Wu V, Wismeijer D, Coucke W, Evans C. The accuracy of static computer-aided implant surgery: a systematic review and meta-analysis. *Clin Oral Implants Res*. (2018) 29:416–35. doi: 10.1111/clr.13346

43. Widmann G, Bale RJ. Accuracy in computer-aided implant surgery – a review. *Int J Oral Maxillofac Implants*. (2006) 21:305–13.

44. Cassetta M, Bellardini M. How much does experience in guided implant surgery play a role in accuracy? A randomized controlled pilot study. *Int J Oral Maxillofac Surg*. (2017) 46:922–30. doi: 10.1016/j.ijom.2017.03.010

45. Block MS, Emery RW, Cullum DR, Sheikh A. Implant placement is more accurate using dynamic navigation. *J Oral Maxillofac Surg*. (2017) 75:1377–86. doi: 10.1016/j.joms.2017.02.026

46. Pellegrino G, Bellini P, Cavallini PF, Ferri A, Zacchino A, Taraschi V, et al. Dynamic navigation in dental Implantology: the influence of surgical experience on implant placement accuracy and operating time. An in vitro study. *Int J Environ Res Public Health*. (2020) 17. doi: 10.3390/ijerph17062153

frontiers | Frontiers in Oral Health

TYPE Original Research
PUBLISHED 29 January 2024
DOI 10.3389/froh.2023.1290713

OPEN ACCESS

EDITED BY
Giuseppe Minervini,
Università della Campania Luigi Vanvitelli, Italy

REVIEWED BY
Fermín E. González,
University of Chile, Chile
Rocco Franco,
University of Rome Tor Vergata, Italy

*CORRESPONDENCE
Melanie Nasseripour
melanie.nasseripour@kcl.ac.uk

RECEIVED 07 September 2023
ACCEPTED 07 December 2023
PUBLISHED 29 January 2024

CITATION
Nasseripour M, Hasan A, Chapple L, Chopra A, Cracknell L, Maiter Z and Banerjee A (2024) An evaluation of the use of caries risk/susceptibility assessment in an undergraduate dental curriculum.
Front. Oral. Health 4:1290713.
doi: 10.3389/froh.2023.1290713

An evaluation of the use of caries risk/susceptibility assessment in an undergraduate dental curriculum

Melanie Nasseripour[1]*, Adam Hasan[1], Liz Chapple[2], Anusha Chopra[1], Lucy Cracknell[1], Zahraa Maiter[1] and Aviijit Banerjee[3]

[1]Centre for Dental Education, Faculty of Dentistry, Oral and Cranio-Facial Sciences, King's College London, London, United Kingdom, [2]OHI ltd., Birmingham, United Kingdom, [3]Centre for Oral, Clinical & Translational Sciences, Faculty of Dentistry, Oral and Cranio-Facial Sciences, King's College London, London, United Kingdom

There has been a paradigm shift in patient care with regards to delivering better oral health, towards a team-delivered, person-focused, risk-related model that is known as minimum intervention oral care (MIOC). Student skills should be developed within the undergraduate dental curricula to ensure that graduating dentists and other oral healthcare team members are able to provide phased personalised care plans alongside behavioural management support to patients/caregivers to prevent and manage oral disease in the long term. The purpose of this study is to establish that using an adjunctive caries risk/susceptibility assessment (CRSA) technology (PreViser) had an impact on the behaviour, perception, and knowledge of dental undergraduate students and their clinical teachers, regarding the benefits of such an oral health assessment in the management of patients. Four cohorts of students who did not have exposure to the caries risk susceptibility software were compared with those who did. This study was conducted using a mixed methods approach using a convergent parallel design consisting of collecting quantitative data through questionnaires presented to four cohorts of Year 4 dental students ($n = 150$ per cohort) and their clinical teachers ($n = 10$) and qualitative data from structured interviews with students ($n = 5$) and teachers ($n = 7$) with suitable statistical analysis and interpretation.

Results: Generally, the items that exhibited statistical significance, when reviewed, showed better behaviour, perception, and knowledge towards CRSA in the Group C (BDS4-22T1) cohort in comparison with the Group A (BDS3-20T2) cohort. The Group D (BDS4-22T2) students felt more confident using the PreViser as a CRSA tool. When comparing the Group C and Group D data, we note that the students from the Group C cohort were more likely to carry out a diet analysis for their patients and were less likely to be negatively impacted by time constraints compared with the Group D students. Both cohorts were equally confident in using the PreViser for CRSA. From a qualitative perspective, although competence and confidence appeared high, the students and teachers acknowledged that they would need more support to use it chairside. The main barrier listed to using PreViser rested in the fact that clinical teachers either preferred their own ways of assessing or did not know how to use the tool and therefore did not encourage using it. Those who did use PreViser highlighted that it was straightforward to use and was a systematic approach, enabling communication with the patients as there is 'evidence' to back up the clinical recommendations.

Conclusion: The cumulative benefit of training and use (even limited) had an impact on the students' knowledge, competence, and confidence regarding CRSA, ultimately facilitating the process of teaching and assisting them in effectively implementing CRSA. The importance of CRSA became more evident immediately following the training. Further research is suggested to understand the factors influencing student behaviour, perception, and knowledge regarding CRSA with the aim to make recommendations on a preferable approach and tool to help streamline CRSA education.

KEYWORDS

dental caries susceptibility, risk assessment, oral health, undergraduate, curriculum

1 Introduction

Considering the preventable nature of behaviour-related oral disease (e.g., dental caries), the provision of clinical treatment as a sole measure of outcome success is dated and inappropriate, with a preventive, long-term approach to maintaining oral health now being recommended (1). Risk/susceptibility assessment facilitates targeted prevention by enabling and supporting conversations with patients or caregivers regarding their patient's combination of risk factors impacting their future oral health outcomes. Furthermore, identifying relevant changes and implementing suitable preventive measures, both within the dental surgery and at home (self-care), to address/minimise these risk factors, can contribute to achieving optimal long-term oral health outcomes.

There has been a paradigm shift in patient care within delivering better oral health, towards a team-delivered, person-focused, risk-related model, that is minimum intervention oral care (MIOC) (2–5). Person-focused care requires educating dental professionals on oral health risk/susceptibility factor assessment, that is, the risk/susceptibility factors for caries, periodontal disease, tooth surface loss, and oral cancer (6). By applying this assessment, a structured, phased, personalised care plan can be developed with an engaged, motivated patient/caregiver, to change behaviours and achieve successful long-term oral healthcare maintenance.

The undergraduate dental curricula should prioritise the development of student skills to ensure that graduating dentists and other members of the oral healthcare team are capable of providing personalised care plans based on person-focused oral health risk/susceptibility assessments, as well as offering behavioural management support to patients.

The Faculty of Dental, Oral and Cranio-facial Sciences, King's College London (FoDOCS), a UK teaching institution, has a long history of embedding Minimum Intervention Oral Health Care including Caries Risk/Susceptibility Assessment (CRSA) throughout its 5-year undergraduate curriculum of the Bachelor of Dental Sciences (BDS) programme. From an educational perspective, the learning outcomes are mapped to the registration outcomes set by the regulatory body for the UK dental profession (7), requiring dentists to 'evaluate the health risks of diet, drugs and substance misuse, and substances such as tobacco and alcohol on oral and general health and provide appropriate advice and support'.

Teaching/education must include evaluating the learning process and its effects on both student clinical practice and patient health. Continuous assessment of student behaviour, perception, and knowledge of CRSA from 2017 onwards informed the changes which were implemented within the current dental curriculum. The outcome of these assessments, in particular, highlighted the usefulness of a systematic approach for evaluating the risk/susceptibility to oral health at the chairside in clinics to support students in improving clinical outcomes for their patients. The choice of the online PreViser technology was informed by the need to have a comprehensive oral disease risk/susceptibility assessment tool for caries, periodontology, oral cancer, and tooth surface loss, which was applicable in an undergraduate academic environment.

PreViser is an online tool used to evaluate the risk/susceptibility to oral diseases, as well as assess oral health which, up to 2023, was supplied in the United Kingdom by OHI Ltd, a joint venture with the University of Birmingham. Currently, PreViser is available worldwide through PreViser Corporation. Since 2017, oral disease risk assessment has been embedded in undergraduate training at the University of Birmingham Dental School, and the use of PreViser formed a required competency. In the United Kingdom, 845 dentists performed 160,000 assessments using the Denplan PreViser Patient Assessment (DEPPA) version of the software. In the United States, PreViser is owned by an insurance company, NE Delta Dental, that promotes an (8) approach to patient care and primarily uses PreViser as the entry into enhanced benefits for specific conditions (https://www/healththroughoralwellness.com). Over 1 million PreViser risk assessments have been completed across the United States, and more than 150 schools/universities/colleges in 43 states are registered users of PreViser Clinical Suite (source: PreViser Corporation).

1.1 Aims and objectives

The purpose of this study is to identify whether using adjunctive CRSA technology (PreViser) had an impact on the behaviour, perception, and knowledge of dental undergraduate students and their clinical teachers regarding the benefits of oral health assessment in the management of patients.

The working hypothesis was that the impact of using PreViser would enhance student behaviour, perception, and knowledge of oral health risk assessment in the management of patients.

Having assessed the feasibility of implementing CRSA technology at FoDOCS clinical facility in Guy's and St Thomas' Hospital Trust (GSTT), these results would help inform future changes in the broader curriculum reviews regarding the advancement of Oral Health Risk/Susceptibility Assessment using such adjunctive technology.

2 Materials and methods

This study was conducted using a mixed methods approach with a convergent parallel design; quantitative data (from questionnaires) and qualitative data (from interviews and focus groups) were collected and analysed to determine whether student behaviour, perception, and/or knowledge had changed. The areas of convergence or divergence between the qualitative and quantitative results should be discussed. The quantitative and qualitative data were collected via questionnaires and interviews, enabling us to establish a detailed and accurate picture of the characteristics and behaviours of a particular population (here, students) towards a specific topic (here, CRSA). The ethical approval was obtained from King's College London Research Ethics Committee (ref: LRS-20/21-20542).

2.1 Description of participants

The data collected from the research project consisted of two groups of participants: the student group and the clinical teacher group.

2.1.1 Student group

The student cohort using PreViser was the BDS4 academic year 2021–2022 cohort. We looked at their responses to the student questionnaire, before (BDS4-22T1) and after (BDS4-22T2) the PreViser training and use. We also compared their questionnaire responses to an equivalent cohort in academic year 2019–2020 as explained in Table 1:

- BDS4-22T1/Group C with BDS3-20T2/Group A.
- BDS4-22T2/Group D with BDS4-20T2/Group B.

In addition, the BDS4-22T2 students were invited to attend online interviews conducted through Microsoft Teams (MS Teams) to discuss their behaviour, perception, and knowledge of CRSA, with a specific focus on PreViser. Due to practical logistical challenges, we had to interview each member of the student focus group separately (clinic timetabling clashing with the ability for all to attend the same session).

2.1.2 Clinical teacher group

The group of clinical teachers questioned on PreViser was the Undergraduate Clinical teachers who would have had direct clinical teaching of the BDS4-22 cohort throughout academic year 2021–2022.

We looked at their responses to the clinical teacher survey before and after the PreViser training and use.

In addition, the clinical teachers were invited to attend online focus groups using MS Teams to discuss their behaviour, perception, and knowledge of CRSA, with a particular focus on PreViser. Due to practical logistical challenges (teaching timetabling clashing with the ability for all to attend the same session), we had to break the group into three separate focus group discussions.

2.1.3 Intervention

We introduced PreViser to students in the 4th year of the programme (BDS4-22 students, $n = 150$) and their Care Planning Clinics (CPC) teachers ($n = 10$). All participants were calibrated to use PreViser as an Oral Health Risk Assessment tool (see below section on the training of teachers and students) to support care planning for a duration of 5 months starting 1 November 2021 to 30 April 2022. There were a total of 102 PreViser assessments by students during this period of time.

The details of the teacher and student training to calibrate their proficiency in using PreViser:

The students in BDS3 and BDS4 get two formal lectures and seminars each year on Oral Health Risk/Susceptivity Assessment including specifically CRSA in Years 3, 4, and 5 of their undergraduate curriculum with PreViser reviewed among other tools. In the summer of 2018, the clinical staff were made aware of PreViser as part of their training to become King's College London Behaviour Change champions, and all clinical teachers are involved in delivering the Conservative and Minimal Invasive dentistry (Cons/MI) seminars which also cover CRSA tools including PreViser. In preparation for the start of the PreViser pilot study, we implemented the following training for the students and teachers:

August–September: Prior to the start of the PreViser pilot study at care planning clinics in October:

- Materials posted on the Keats BDS4 year group page (virtual learning space):
  - ➢ PreViser documents.
  - ➢ seminars on CRSA with associated reading list.
  - ➢ Narrated powerpoint presentations on the use of PreViser.
- Seminar: 1 h on PreViser and behaviour change.
  - ➢ Recorded and posted as additional resource.

We specifically analysed the data from cohorts summarised in Table 1 below.

To establish the impact of the PreViser pilot (which includes the training for and the actual use of PreViser in the pilot) on our students' behaviour, perception, and knowledge about CRSA, we compared the questionnaire responses of the following pairs of cohorts:

- Group A with Group C.
- Group B with Group D.
- Group D with Group C.

We sent out a call via email for students in the 4th year of the programme (BDS4 – 22 students, $n = 150$) and their care planning clinic teachers ($n = 10$) to take part in our research project on

TABLE 1 Abbreviations and participant denominations. T1 refers to the start of the academic year, and T2 refers to the end.

Abbreviation	Student cohort description	Equivalence	CRSA education and training overview		
			Similarities	Differences	
BDS3-20T2/Group A	BDS3 cohort at the end of the academic year 2019-2020	As there is no teaching or clinics over the summer we can consider that BDS3-20T2 are equivalent to BDS4 at start of the year in T1	• same profile (age/gender/clinics) • same numbers in the cohort and participating in the study • same curriculum in Cons/Mi	No PreViser-specific training or use	
BDS4-20T2/Group B	BDS4 cohort at the end of the academic year 2019–2020			No PreViser-specific training or use	
BDS4-22T1/Group C	BDS4 cohort at the start of the academic year 2021–2022, and therefore before the start of the study.			PreViser-specific training as outlined	entire BDS3 clinical experience impacted by COVID-19 although the rest of the curriculum was delivered
BDS4-22T2/Group D	BDS4 cohort at the end of the academic year 2021–2022, and therefore after the end of the study.			PreViser-specific training as outlined and used PreViser in CPC clinics	

assessing students' behaviour, perception, and knowledge in CRSA, which included two phases in the research project:

Phase 1: Quantitative phase consisting of anonymous questionnaire completion.

After which, we invited those who had completed Phase 1 to attend Phase 2.

Phase 2: Qualitative phase consisting of one-on-one interviews for students and a focus group on MS teams for the teacher group.

2.2 Quantitative research

Independent of this study, questionnaires submitted to clinically active students between 2017 and 2021 assessed their behaviour, perception, and knowledge on CRSA (9–16).

Prior to the start of the trial and after completion, the student and teacher participants completed a student or clinical teacher questionnaire, respectively:

- Students were asked questions to gauge their behaviour, perception, and knowledge in terms of oral health assessment.
- Clinical teachers were asked questions to gauge their students' behaviour and perception in relation to caries susceptibility assessment.

Kirkpatrick's four levels of training evaluation framework served as the foundation for the student questionnaire design (Supplementary Appendix 1), which was comprised of four sections:

- Demographic section: four questions covering undergraduate team allocation, sex, age, and year group, as well as if BDS degree is their first degree or not.
- Behaviour section: 13 questions assessing student behaviour towards caries risk assessment.
- Perception section: 13 corresponding questions assessing student perception towards caries risk assessment.

The teacher questionnaire (Supplementary Appendix 2) with its seven questions was designed to complement the student questionnaire by assessing the teacher's perception of the students behaviour/perception and knowledge on CRSA.

2.3 Qualitative research

The questionnaire responses were supplemented with online Microsoft Teams student interviews and teacher focus groups post-intervention, using interview guides mirroring the student and teacher questionnaires (Supplementary Appendices 3 and 4, respectively). The purpose was to further explore, in detail, the participant responses for each of the study outcomes along the Affordability, Practicability, Effectiveness, Acceptability, Side-effects, Equity (APEASE) criteria to evaluate behavioural interventions in terms of process (17).

For this phase, we proceeded with purposive sampling within the participants of the quantitative phase for both the student and teacher groups (i.e., from those who completed the survey). A total of five Year 4 students and seven clinical teachers attended the second phase.

2.4 Data analysis

2.4.1 Quantitative analysis

This literature review highlighted that the most common method was the use of a questionnaire survey to gather opinions regarding caries risk assessment from students and staff and to also assess the accuracy of their knowledge of caries risk assessment and subsequent management (11–16).

Both questionnaires used variations of a Likert scale, which allowed us to convert the data to an ordinal scale of 1–5. These data were then entered into SPSS for analysis [IBM Corp. released 2021. IBM SPSS Statistics for Windows, version 28.0.1.1 (15) Armonk, NY: IBM Corp].

Due to the variability of our Care Planning rotation in the curriculum, we are looking at data from a cohort-specific perspective rather than focusing on participant-specific data (i.e., 22 T1 and 22 T2 participants were not the same individuals but from the same cohort with the same exposure to training, curriculum, and PreViser in care planning clinics).

As baseline, we also used the data from the same questionnaire that was administered prior to the COVID-19 pandemic in the academic year 2019–2020 as part of an undergraduate research

project at FoDOCS, with relevant ethical clearance and consent obtained from the participants.

2.4.2 Qualitative analysis

The sessions were held online using Microsoft Teams meetings. The meetings were run using the guides attached in the Appendices. The sessions were recorded, with the existing written consent from the participants and verbally re-confirmed prior to starting the recording.

The recorded sessions were stored in the Microsoft 360 King's College London (KCL) One Drive (General Data Protection Regulation GDPR compliant) and accessible only to the five KCL members of the PreViser research team (MN, KA, AV, AC, ZM). MS Stream generates automated transcriptions which were then reviewed by two of the team members after the calibration session (AC, MN). MN proceeded with the familiarisation with the transcripts, followed by an initial coding highlighting phrases or sentences—and coming up with shorthand labels or 'codes' to describe their content. Next, we identified patterns among the codes, and proceeded with finalising the relevant themes. We returned to the transcripts and reviewed the themes (AC, LC, ZM) before proceeding with the final coding using the agreed themes.

Thematic analysis was the technique employed to identify commonalities and differences in the ideas and phrases that students and teachers articulated in their narratives and that can indicate some degree of importance allocated to a specific thought or occurrence. This research used three aspects of identifying the themes (18):

- Recurrence criterion refers to concepts that are repeated using similar words or phrases.
- Repetition criterion means that an idea is conveyed with the use of the same words.
- Forcefulness refers to the emphasis applied to a concept.

The write-up of the results is presented below.

3 Results

3.1 Demographic data

Teacher demographics were not recorded. All clinical teachers have at least 10 years of experience in general dental practice and supervise Year 4 undergraduate students 1 or 2 days a week. We provide induction and regular calibration sessions to support them in delivering the curriculum to our students. These clinical teachers (T1 $n = 11$, T2 $n = 9$) supervise students during patient treatment and therefore care planning. The student demographic data is presented in the Table 2 below and shows a similar distribution in terms of age, sex and ICC team in all groups.

3.2 Quantitative results

3.2.1 Student group

Tests were conducted to determine the association between the categorical data, response, and the BDS4/BDS3 group using Fisher's exact test since the expected cell value was less than 5 for all the questionnaire questions.

The 5-point Likert scales were converted into numbers (strongly agree = 1, agree = 2), and it is important to note that some questions had reverse scales. Since the data were non-normal ordinal data, we conducted Mann–Whitney U tests to assess the difference in responses to our CRSA questionnaire from Group A/Group B/Group C, and Group D. The level of significance was set at 5%.

3.2.1.1 Group A/Group C comparison

When comparing the data set for the Group A and Group C cohorts, we find statistically different relevant data with ($p < 0.05$) for the questions in the Table 3 below:

Looking at the Boxplots.

I carry out a diet analysis for my patients.

There is a statistically significant association observed between the response and the year group (Fisher's exact test, $p < 0.001$), wherein Group C demonstrates a higher frequency (almost always or always) of conducting diet analyses. This is also reflected in the lower median score of 2 and interquartile range (IQR) = 2 in Group A compared with the median score of 3 (IQR = 1) in Group C (Figure 1).

TABLE 3 BDS3-20T2-BDS4-22T1 (Group A/Group C) analysis test statistics.

Question	Mann–Whitney *U*	*p*-value
I carry out a diet analysis for my patients	99.5	<.001
I ask patients about their fluoride use	123	0.003
Over the past semester, I did not perform formal caries risk assessment because of time constraints.	99	<.001
When have you considered fluoride varnish application for High Caries Risk	112	0.007
When have you considered fluoride varnish application for Mod Caries Risk	121.5	0.017
I am confident in using the following Caries Risk Assessment tools: PreViser	100	0.002
CRA includes assessment of the following factors: tick all those that apply:	90	0.006

TABLE 2 The demographic data of the student participants.

		Age					Sex				ICC Teams				
		20–25	25–30	30–35	Missing	Total (*n*)	Female	Male	Missing	Total (*n*)	21	25	26	Missing	Total (*n*)
Year Group	Group D	18	5			23	13	10		23	6	9	8		23
	Group C	19	3			22	17	5		22	8	8	6		22
	Group B	14	9	1		24	12	11	1	23	7	7	10		24
	Group A	18	1	1	1	21	16	4	1	21	5	7	5	4	21

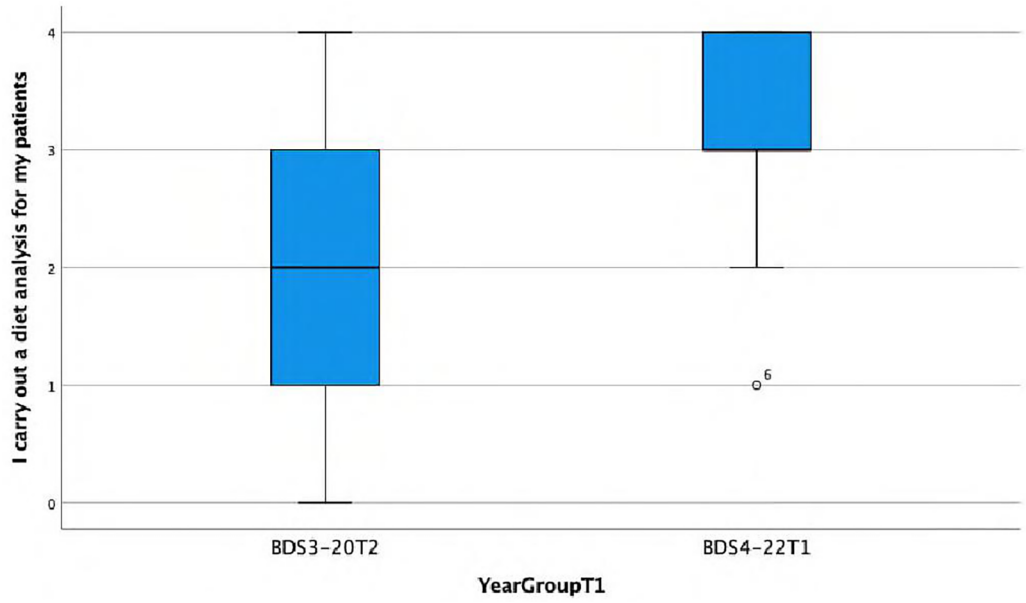

FIGURE 1
Boxplot showing differences between Group A and Group C in carrying out diet analysis for patients.

I ask patients about their fluoride use.

There is a statistically significant association observed between the response and the year group (Fisher's exact test, $p = 0.003$), indicating that Group C has a higher frequency (almost always or always) of asking patients about fluoride use. This is also reflected in the lower median score of 3 (IQR = 2) in Group A compared with the median score of 4 (IQR = 0) in Group C.

Over the past semester, I did not perform formal caries risk assessment because of time constraints.

There is a statistically significant association observed between the response and the year group (Fisher's exact test, $p < 0.001$), suggesting that the BDS4 group has a higher frequency (disagreeing or strongly disagreeing) of the statement 'over the past semester…' This is also reflected in the lower median score of 2 (IQR = 2) in Group A compared with the median score of 2.5 (IQR = 1) in Group C (Figure 2).

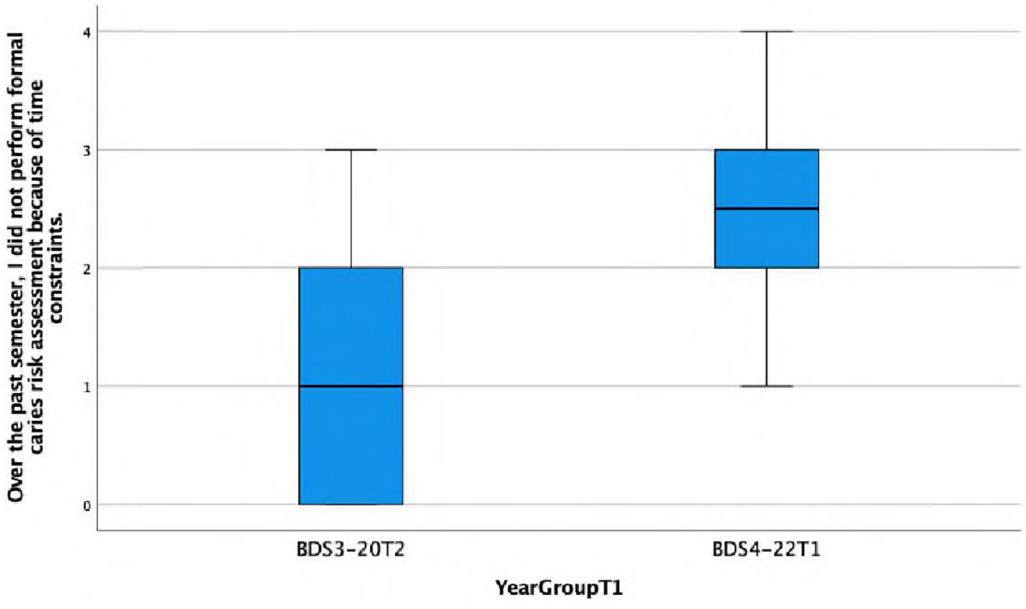

FIGURE 2
Boxplot showing differences between group A and Group C in performing formal caries risk assessment due to time constraints.

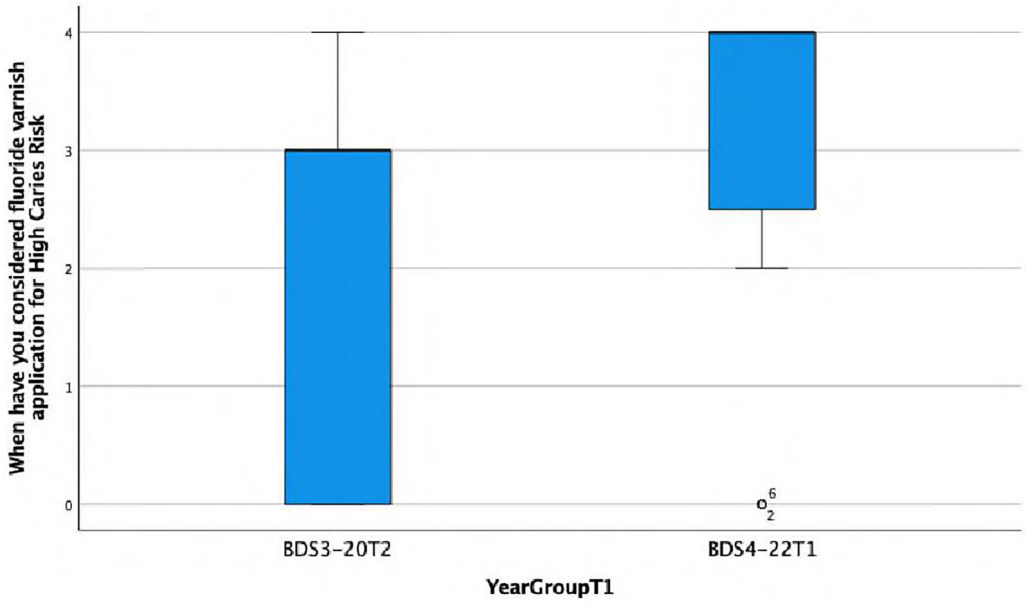

FIGURE 3
Boxplot showing differences between Group A and Group C in considering fluoride varnish application for high caries risk.

When have you considered fluoride varnish application for High Caries Risk.

There is a statistically significant association observed between the response and the year group (Fisher's exact test, $p = 0.007$), with the BDS4 group more frequently (always) considering high risk. This is also reflected in the lower median score of 3 (IQR = 3) in Group A compared with the median score of 4 (IQR = 1.5) in Group C (Figure 3).

When have you considered fluoride varnish application for Mod Caries Risk.

There is a statistically significant association found between the response and the year group (Fisher's exact test, $p = 0.017$), with the BDS4 group tending to consider fluoride varnish more frequently (almost always) for patients with moderate caries risk. This is also reflected in the lower median score of 1 (IQR = 2) in Group A compared with the median score of 2.5 (IQR = 2) in Group C (Figure 4).

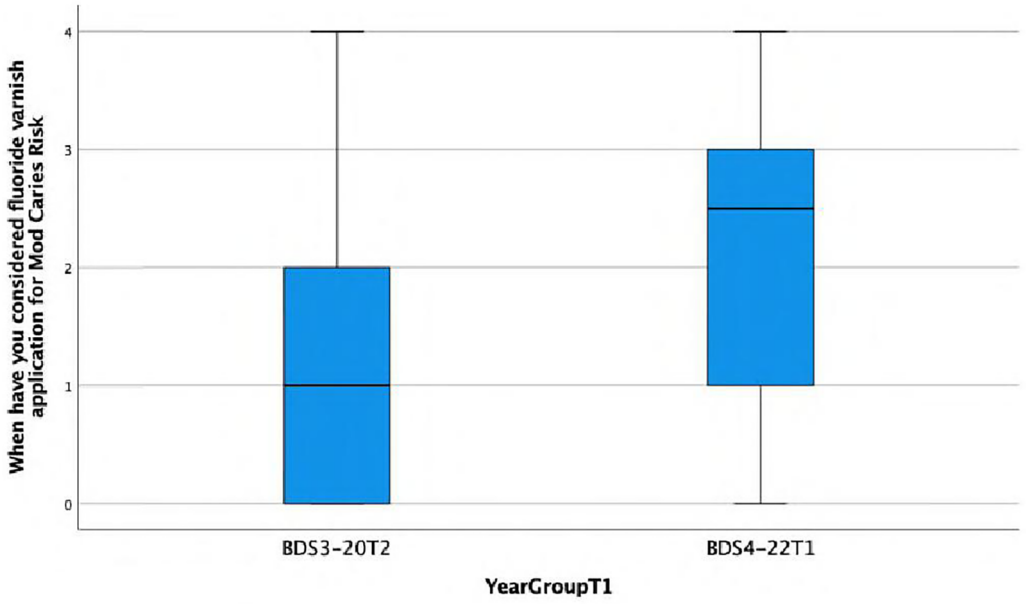

FIGURE 4
Boxplot showing differences between Group A and Group C in considering fluoride varnish application for moderate caries risk.

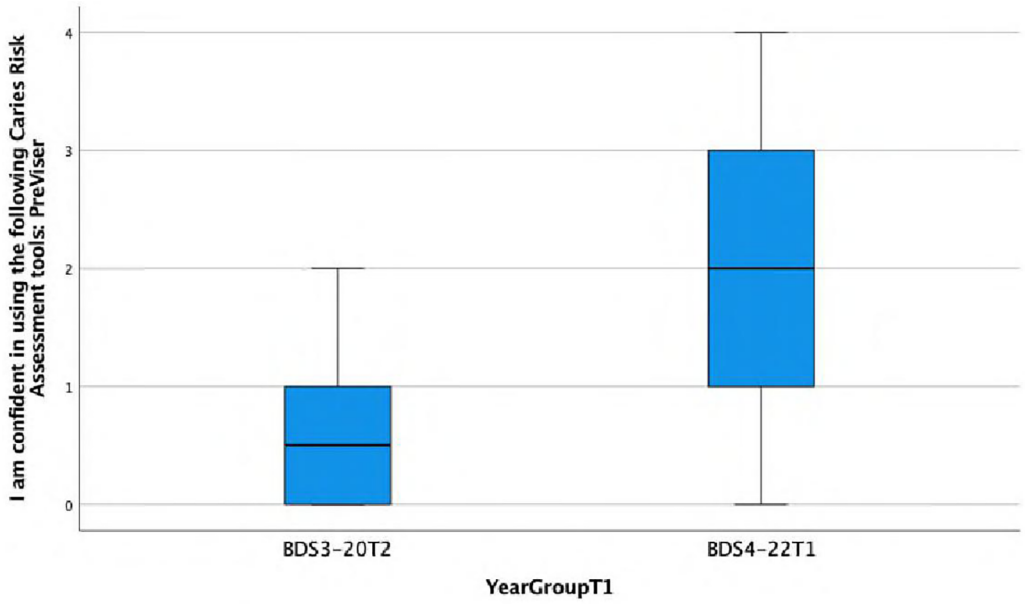

FIGURE 5
Boxplot showing differences between Group A and Group C in confidence in using a caries risk assessment tools: PreViser.

I am confident in using the following Caries Risk Assessment tools: PreViser.

There is a statistically significant association observed between the response and the year group (Fisher's exact test, $p = 0.002$), with the BDS4 group showing a higher frequency of agreeing or strongly agreeing with the statement 'I am confident in using …' This is also reflected in the lower median score of 0.5 (IQR = 1) in Group A compared with the median score of 2 (IQR = 2) in Group C (Figure 5).

CRSA includes assessment of the following factors: tick all those that apply

There is a statistically significant association observed between the response and the year group (Fisher's exact test, $p = 0.006$), with the BDS4 group recognising more of the CRSA factors than the Group A. This is also reflected in the lower median score of 7 in Group A compared with the median score of 8 in Group C.

3.2.1.2 Group B/Group D comparison

When comparing the data set for the Group B and Group D cohorts, we find statistically different relevant data with ($p < 0.05$) for the questions in the Table 4 below:

The corresponding Boxplot are as follows:

I am confident in using the following Caries Risk Assessment tool: PreViser.

There is a statistically significant association observed between the response and the year group (Fisher's exact test, $p = 0.015$), with the Group D more frequently disagreeing or strongly disagreeing with the statement 'I am confident in using …' This is also reflected in the lower median score of 1 (IQR = 1) in Group B compared with the median score of 2 (IQR = 2) in Group D (Figure 6).

TABLE 4 BDS4-20T2-BDS4-22T2 (Group B/ Group D) analysis test statistics.

Question	Mann–Whitney *U*	*p*-value
I am confident in using the following Caries Risk Assessment tools: PreViser	166.5	0.015

3.2.1.3 Group C/Group D comparison

When comparing the data set for the Group C and Group D cohorts, we find statistically significant differences ($p < 0.05$) for the questions in the Table 5:

The Boxplots are as follows:

I carry out a diet analysis for my patients.

There is a statistically significant association found between the response and the year group (Fisher's exact test, $p = 0.039$), with the BDS4-22T1 group more frequently (almost always or always) carrying out diet analysis. This is reflected in a median value of 3, a first quartile (Q1) value of 3, and a third quartile (Q3) value of 4 for Group C, i.e., 50% of the data are above a score of 3. However, Group D while having a median score of 3 has a Q1 value of 1 and a Q3 value of 3, i.e., 50% of the data are below a score of 3 (Figure 7).

Over the past semester, I did not perform formal caries risk assessment because of time constraints.

There is a statistically significant association found between the response and the year group (Fisher's exact test, $p = 0.023$), indicating that Group D's behaviour towards performing a CRSA is more likely to be negatively impacted by time constraints. This is also reflected in the lower median score of 2 (IQR = 1) in Group D compared with the median score of 2.5 (IQR = 1) in Group C (Figure 8).

I am confident in using the following Caries Risk Assessment tools: PreViser.

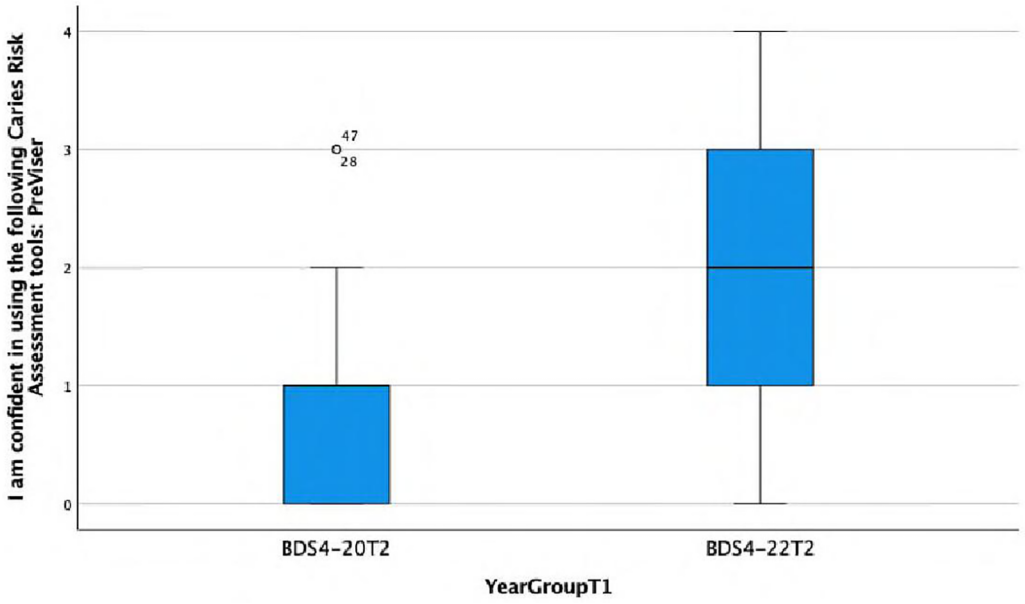

FIGURE 6
Boxplot showing differences between Group B and Group D in confidence in using a caries risk assessment tools: PreViser.

TABLE 5 BDS4-22T1/BDS4-22T2 (Group C/Group D) analysis test statistics.

Questions	Mann–Whitney *U*	*p*-value
I carry out a diet analysis for my patients	158	0.039
Over the past semester, I did not perform formal caries risk assessment because of time constraints.	157	0.023

There was no statistically significant difference observed between the response and the year group, indeed regarding confidence in using PreViser for CRA, both Group C and Group D cohorts provided exactly the same answers, exhibiting the same distribution and median (Figure 9).

3.2.3 Teacher

Regarding the Teacher Data T1 and T2 teachers

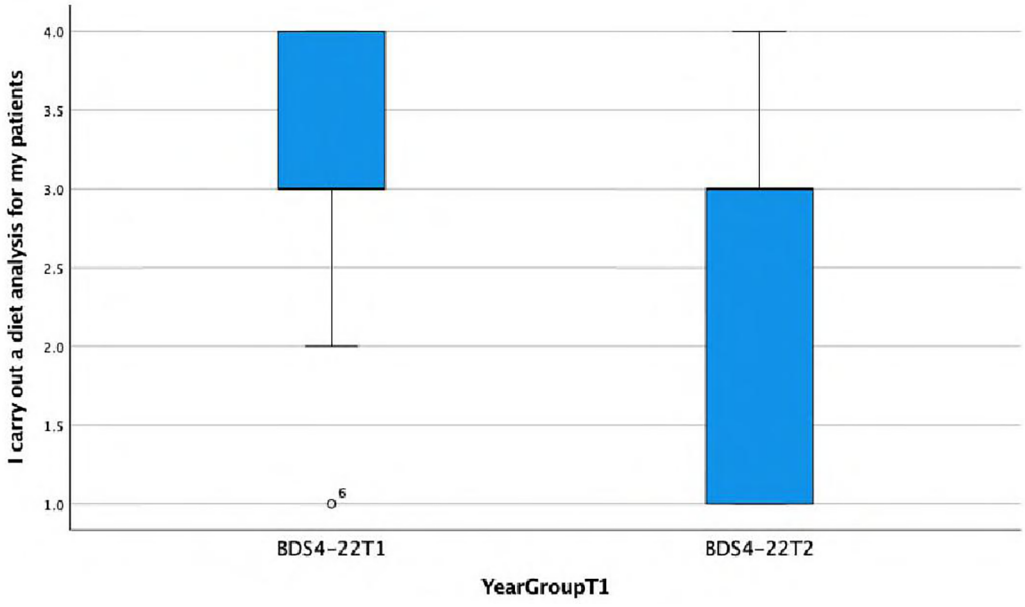

FIGURE 7
Boxplot showing differences between Group C and Group D in carrying out diet analysis for patients.

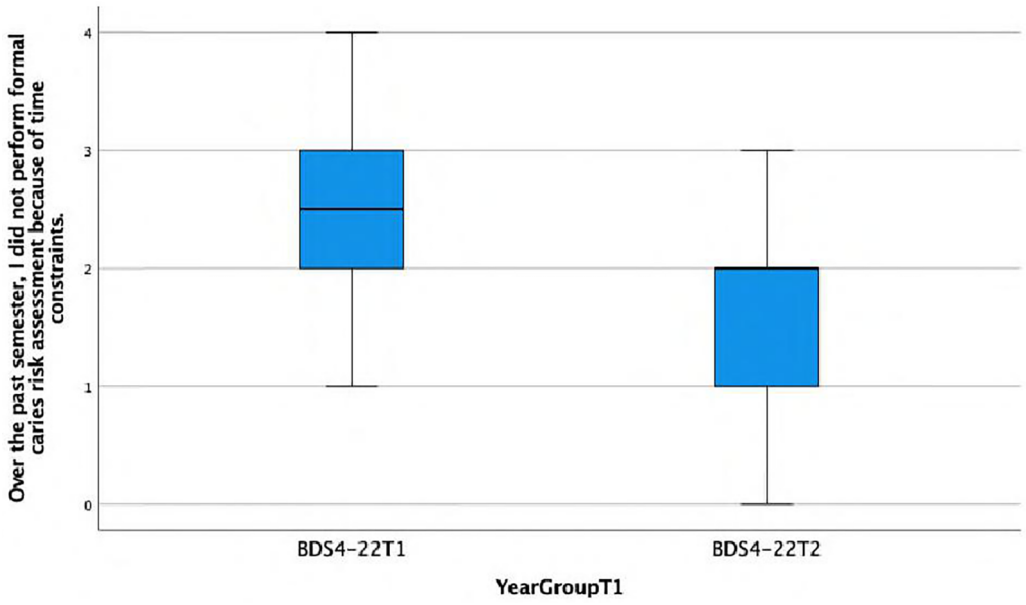

FIGURE 8
Boxplot showing differences between Group C and Group D in performing formal caries risk assessment due to time constraints.

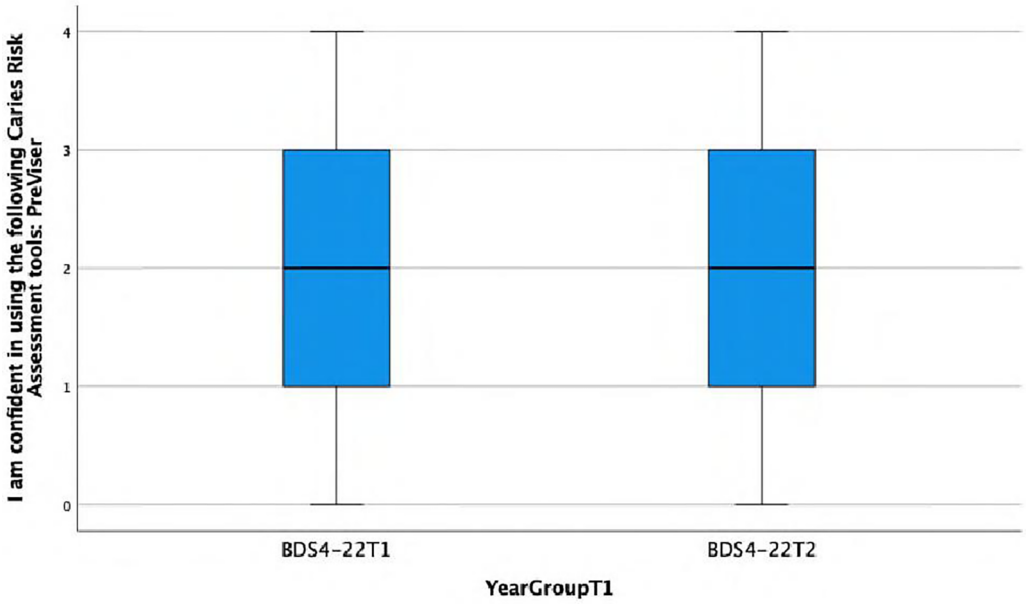

FIGURE 9
Boxplot showing differences between Group C and Group D in confidence in using a caries risk assessment tools: PreViser.

Due to rotation variability, we are looking at the data from a cohort-specific perspective rather than a participant-specific data.

The TeacherT1($n = 11$) and TeacherT2 ($n = 9$) participants belonged to the same cohort and had the same level of exposure to training, curriculum, PreViser in CPC, and student supervision. There was no statistically significant difference observed in the responses provided by the teachers at T1 and T2.

Upon examining the mean plots graph below, it is evident that the teachers usually perceived the following in the Group D cohort compared with the Group C cohort:

- more knowledgeable about CRA.
- more competent about CRA.
- more confident about CRA.
- easier to teach CRA.
- easier to supervise delivering CRA.

3.3 Qualitative Resutls

A thematic analysis was conducted, and Table 6 displays the themes together with relevant quotes from the students and teachers.

3.3.1 Student group

Overall, there was a positive perception from the students towards PreViser, highlighting that PreViser is straightforward to use.

They liked the systematic approach it gave to oral health risk assessment. Having this clear structure translated into good communication with the patients as it highlighted the causes of disease and prompted topics of discussion. It can enable difficult conversations with patients as there is 'evidence' to back up the clinical recommendations.

The students generally seemed confident in oral health risk assessment and felt they could complete this competently and independently. This reflected their training throughout the

TABLE 6 Thematic analysis results summary.

Themes	Student quotes	Teacher quotes
PreViser Impact	Student 2: I think that definitely, my knowledge over this year has increased a lot in terms of caries risk assessments. Especially, I think you know, PreViser has been a big part of it because there was a couple video and things that we needed to watch, and the training we needed to do as well for the PreViser, which definitely helped.	Teacher 7: Do you use it in practice? And I said, well, I don't. But I do think it's a very useful tool. Especially for inexperienced dentists, so newly qualified dentists, students when they can't really work out the risk assessment, can't really work out the risks very easily. I think it's really useful.
Competence	Student 5: My competence kind of based on when the clinician comes up afterwards and does the same thing and see if they add anything extra to my kind of history and examination and I would say that: The one time I maybe, maybe my competence is being challenged is around older restorations, where there's leaking margins—that sensitivity I don't think is quite there. But I think otherwise picking up disease seems to be equivalent to what the clinician finds.	Teacher 4: The more we're able to use it and practice with it, I think, the more competent we will get.
Confidence	Student 1: I think I would be able to carry out an oral health risk assessment now by myself. I think I've had enough practice now and enough knowledge to be able to put it into practice confidently.	Teacher 6: It is very new and still we are in private practice; we are not using this system. So just we should give, you should give it time. PreViser also at the beginning we said that 'no, why, why' but after a short time, I'm sure that we will find how advantageous it is, how good it is.
Education/Pedagogy	Student 5: I think I've got a fair grounding and understanding of what other major risk factors for developing both of those diseases, including the general risk factors for patients and then also maybe those little extra ones that might increase their susceptibility.	Teacher 1: With the case with risk assessment it's just how we were taught, the dental students So I have this knowledge bank already in my brain. So I have to rely on my training and expertise in oral healthcare assessment, which I think is competent.
Communication (including validation/validity)	Student 2: And I think also to assess their interests. And you know, because after you do all health assessment you have the discussion with them. But like if they're for example, someone that's not really motivated by like, you know, like we've had lectures on motivational interviewing and how to, you know, ask, advise, act and things like that.	Teacher 3: It's something, really, something there for the patients to see and they understand it more in, you know, in layman terms. Which is eventually, you know, is all about treating them and getting them to change their ways and diet and risk and things like that. They understand these things in a more layman fashion. Whereas with the students at that stage of their career or education, they're still trying to learn the skills of communication. How to communicate in a way which is not so technical.
Specific Training	Student 2: And I also think like having kind of an in person training session would be very, very beneficial to us using PreViser.	Teacher 3: There needs to be quite a meticulous training programme so that people are quite efficient with it. I think that you know, in terms of the tool itself is brilliant. I think the issue generally on clinic is time and so if there's an efficient training programme and maybe like a day is not only a training programme for the students for the staff as well.
Role modelling	Student 1: It depends on the tutor … and I think because of that first session then afterwards no one did it just because they thought oh this tutor doesn't want us to do it, so there's no point in doing it.	Teacher 1: They're keen to know what I do in practice. And I think one of them did say, are you using this Doctor… and I said 'No, I'm not using it in practice'. And perhaps, I don't know, then there could be a downside for me telling them that. Because then it probably makes them think why are they doing it.
Embed in Electronic Patient Record	Student 3: The only thing is, I think if it was integrated, would say salud or if not just like one system we used to access both like if it was integrated into the history, for example, that would have been really good because I think having multiple programmes to use it has it does make it a little bit difficult	Teacher 2: The less obstacles to them being able to do it—you know, the kind of logging in or you know, all that sort of stuff—the more streamlined it is, the easier it is for them to not have an excuse not to do it.
Repetition/Time constraints	Student 5: Sometimes if there are time pressures on the clinic, especially getting into UM diagnostics, like radiology or there's a lot waiting Maybe the detail, the depth of the oral health risk assessment that you go into. And also the integration, I mean using multiple systems is never um, that's always tricky, isn't it?	Teacher 1: I think my initial concern was that it would take them away from the learning of clinical practice, but having seen the few students who did it, it didn't seem to have an impact on their time with the patient, and because they didn't ask me for any involvement or engagement, I can't see how it's going to take up my time in addition.

(*Continued*)

TABLE 6 Continued

Themes	Student quotes	Teacher quotes
Systematic/Approach	Student 3: I think having PreViser is good, UM in like sort of, you're having that systematic approach like you said. It takes you through the whole process and you kind of can discuss the reasoning for different questions. You're asking the patient as you're going through.	Teacher 3: For learners I think it's really good, especially in terms of grasping (the whole the in terms of grasping) treatment planning itself, in terms of the different aspects of treatment planning. You know the order in which you treat the patient and how you're going to, you know, work on the basics first before you go to the definitives.
Specific use (including audit, triage, QAQE, indication)	Student 4: I think also just initially when you're starting clinic, it would probably be good to do it for all patients just so that you can understand how to do it.	Teacher 4: It'll be more case of doing it at initial visit when they're through with that consultation. When they come back, they can do PreViser again. I don't think it's something we can do at every patient visits.
More Experience using it	Student 1: So I think PreViser has needed, I find that I prefer using PreViser than not using PreViser because it does make it easier but then but then again, I've only used it about four times but I haven't really been able to because I haven't really had the opportunity.	Teacher 2: I've only ever done it when I've been supervising students. And obviously it's like anything, the more they do it, the quicker they'll be at doing it
Ease of Use (including independent use)	Student 2: I actually think it's been a very like straightforward, and I think it's been done in a really well like stepwise manner.	Teacher 2: I think as long as the students knew how to log in and kind of do all that, the technical stuff it was. It was quite fine. If they didn't have their or, you know, they weren't familiar with how to log in and do that sort of thing, then it could be a bit of an issue because then they would have to spend time trying to figure out how to do that and then that take up time
Patient care/Practice Setting	No student comments	Teacher 7: at Guy's is that you don't always get that follow up and that sort of continuing treatment and the recalls like you would in practice. I think it'd be a lot easier in practice to do it then it would be in hospital.

Undergraduate degree programme, in addition to PreViser. However unfortunately, many students felt they had not had enough exposure to PreViser on clinic. This was partly due to the infrequency of care planning clinics, where PreViser was being used, and also due to a lack of motivation to use the programme by both students and teachers. Some mentioned forgetting to use the programme, or due to time pressures, and the majority of students commented on the significant influence of the teacher's preferences on whether, and to what extent, oral health risk assessment was performed.

The tool itself can be viewed as repetitive if the students ask questions in addition to those they are instructed to ask regularly. Embedding PreViser into existing electronic patient record systems would support its use, as would more training and small gaps between training and opportunity for clinic use.

It can also be good for triaging patients especially in a large hospital. The students also mentioned the possible use of the tool for auditing patient records in terms of oral health assessment and when looking at resource allocation (treatment).

3.3.2 Teacher group

Several teachers owed their low self-reported confidence and competence in using the PreViser software to the lack of familiarity and limited experience in using the tool. This may explain the 'hands-off approach' when supervising students using PreViser in the clinic. Further calibrated training and guidance was deemed necessary with many reporting the need for additional and more frequent opportunities to practice using the software. Teachers feel confident in their own knowledge, training, and experience to complete oral health assessment independently. However, they were able to recognise the benefit of PreViser as an educational tool for dental students and young dentists to help establish sound foundations, as well as to clinically facilitate communication with patients and support behaviour change.

The teachers had not used PreViser consistently yet felt able to comment on it on the basis that students seemed to be getting on well with it. They recognised the strong influence they have on students' behaviours and acknowledged the need to better encourage students on the benefits and uses of risk assessment.

The following are the teachers' comments on the opportunities related to PreViser:

- ➢ It is good for education purposes.
- ➢ Students could use it with their patients with instructions on a laminated form.
- ➢ It is good for continuity of care in practice.
- ➢ Patients engaged with it more than usual.
- ➢ It improves communication with patients:
  - chairside as helps speaking to patients about their oral health in more layman's terms
  - take home information covered

The teachers also highlighted what they perceived the following to be barriers to using PreViser:

- ➢ lack of time and burden for patient
- ➢ did not feel it compromised clinical practice not to use this tool although an oral health risk assessment is required
- ➢ current dental contracts do not allow a place for it in practice
- ➢ need a meticulous training programme and has to be for all patients in all clinics
- ➢ cannot be used at every visit, perhaps look specifically to initial and recall visits

4 Discussion

Computerised tools incorporating validated algorithms and/or the latest evidence base provide consistent and reproducible assessment of risk to support clinical judgement. There are two systems, PreViser and the PRA (Periodontal Risk Assessment), that have been validated in longitudinal trials for assessing the risk of periodontal disease. Multiple systems (e.g., CAMBRA, Cariogram) have been established for caries risk assessment, although no predictive algorithm has been validated (12, 13, 19). Similarly, there is good knowledge of the risk factors for tooth wear or oral cancer, although no algorithm that combines these factors has been shown in clinical trials to predict disease accurately (20–22). It would, however, be wrong to take this as a reason not to assess the risk and simply focus on fixing the disease. According to WHO, 'Estimation of the potential impact of a health hazard can never wait until perfect data are available since that is unlikely to occur' and 'Considerable gains can be achieved by reducing the risks of factors that are already known'.

PreViser as previously mentioned was chosen as it supports a philosophy of tailored person-focused care based on risk/susceptibility assessment, in line with the pedagogy developed in the undergraduate curriculum. Teaching the new generation to embrace preventative approach will hopefully bring change to the treatment-focused care plan approach in general dental practices.

The impact of introducing PreViser to the 2022 Year 4 cohort was gauged in comparison with preceding 2020 cohorts as described in our Participants section using as base line data from the same questionnaire on Caries Risk/Susceptibility Assessment that was administered prior to the COVID-19 pandemic in academic year 2019–2020 as part of an undergraduate project at FoDOCS with relevant ethical clearance and consent obtained from the participants.

4.1 Group A/Group C

Generally, the items that exhibited statistical significance when reviewed show a better behaviour, perception, and knowledge of the Group C cohort in comparison with the BDS3-20T2 cohort, except for their behaviour towards performing a CRSA which was more likely to be negatively impacted by time constraints that they associated to the process.

We can attribute these differences to the impact of the PreViser training and sensibilisation as the COVID-19 pandemic affected both cohorts (end of the Group A cohort studies and end of Year 2 and all of Year 3 for the Group C cohort).

4.2 Group B/Group D

We note that the Group D students feel more confident using the PreViser as a CRSA tool. This can be attributed to the impact of the PreViser training, sensibilisation, and use as the COVID-19 pandemic affected both cohorts (end of the Group A cohort studies and end of Year 2 and all of Year 3 for the Group D cohort.

4.3 Group C/Group D

When comparing Group C and Group D data, we note that the students from the Group C cohort were more likely to carry out a diet analysis for their patients and were less likely to be negatively impacted by time constraints compared with the Group D students. Both cohorts were equally confident in using PreViser for CRA.

We would perhaps expect clearer differences as Group D also applied PreViser, but the training was more removed from their experience.

The student and teacher interviews provided us more qualitative insight into behaviour, perception, and knowledge on CRSA and the factors impacting them. Generally, we noted the following across the discussions:

Although competence and confidence appear high (knowledge about oral health risk rather than actually being able to do in practice), they acknowledge that they would need more support to use it chairside. The research shows a need to improve students' confidence in performing risk assessment. At the University of Sydney, 60% of third-year students and 71% of fourth-year students found the caries management system useful on clinics. However, 44% of the third-year students found that the protocols are complicated (11). If the students were more comfortable with the protocols, better care could be provided for patients. In Tehran, over 50% of students did not believe that their ability was enough to perform caries risk assessment (13).

The main barrier listed to using PreViser rests in the fact that clinical teachers either prefer their own ways of assessing or do not know how to use the tool and therefore did not encourage using it. The study suggested that perhaps the staff members did not embrace the need for caries management programme despite undergoing training. Staff opinions could have negatively impacted the students' views, thus leading to poor completion of the caries risk assessment forms (23).

Embedding PreViser into existing electronic patient record systems would support its use, as would more training and small gaps between training and opportunity for clinic use. Students' knowledge on risk assessment and appropriate management needs continuous reinforcement and improving. One study reported that only 44.1% of medium and high-risk patients received fluoride varnish. When the patients were reassessed, 25% of patients had been wrongly categorised as medium, when they were in fact high-risk patients (19). Continuous education surrounding caries risk assessment can positively influence its understanding and use. This is also supported by recent evidence from a study (24) at the University of Michigan School of Dentistry. A caries risk assessment model was first introduced in 2011, and soon after its launch, only 43% of patient charts had a completed caries risk assessment. However, from an unspecified 2-year time period close to publication, it was completed in 80%–88% of the cases. The 7-year retrospective study showed that the completion of risk assessment by the dental students had risen over time (25).

This more importantly infers that as a profession, including both students and qualified dentists, on-going and consistent education on caries risk assessment and management needs to occur in order to provide the best patient care in accordance with the current guidelines.

Those who did use PreViser highlighted that it is straightforward to use.

The main positive finding/point is that it is systematic, enables conversations, can alert the gaps between what the student has seen in a person's mouth and what PreViser says about the state of their oral health.

It can enable difficult conversation with patients as there is 'evidence' to back up the clinical recommendations.

It can also be good for triaging patients especially in a large hospital.

The students also mentioned the possible use of the tool for auditing patient records in terms of oral health assessment and when looking at resource allocation (treatment).

Our findings also support the fact that seniority in the programme aligns with a better behaviour, perception, and knowledge towards CRSA. A very recent study assessed the opinions of fifth year dental students from 16 different French dental schools. The results showed positive use of caries risk assessment, with 80% using it in clinical practice. However, it highlighted that this does not necessarily translate to correct and appropriate care planning, as only 55.1% implemented preventative regimes according to the designated risk level (14). Confidence among students also increased with years of education, showing a positive association between years of teaching and perceived confidence (15).

The research suggests an underperformance of accurate caries risk assessment by dental students but also in general practice. One study involving general dental practitioners in France showed that an astonishing 38.4% of respondents did not use caries risk assessment as part of their routine care. Only 4.5% of those claiming to perform caries risk assessment used a specific form. The socio-demographic characteristics of the dental practitioners did influence whether or not caries risk assessment was used (16).

5 Limitations

5.1 COVID-19 impact and PreViser pilot study

We maintained original aims of assessing the benefits of using PreViser in terms of Undergraduate Education and patient care. Considering COVID-19-related constraints in particular to Undergraduate clinics, we had to apply a 12-month delay (started September 2021) for the start of our project, and our care planning clinics ran but with different staff rota each week and students attending on a 1 every 4 weeks rota. Also, it is important to note that only the computers in the care planning clinics were cleared for PreViser use (post Information Governance discussions with the hospital). This limited our staff and students' familiarisation and consistent/systematic use of the PreViser.

5.2 Undergraduate clinics at FoDOCS

Our Undergraduate clinics do not have a formal review/recall framework. The usual pathway is discharging of patients back to their GDP after we have finished the course of treatment agreed at care planning. If patient care is long enough to include a review/recall as required by patient oral health risk assessment and preventative planning, then it is carried out for that patient while still under our care. We could not support a longitudinal approach to CRSA, i.e., at baseline and then review at set recall intervals as would be recommended.

5.3 Questionnaires

Looking at the Teacher questionnaire, in Question 3, the Extremely confident and Very Confident answer options were reversed in the sequence of answers and points. But since none of the teachers chose either one of the options, the data was not impacted.

6 Conclusions

From the student data, the main impact of the PreViser pilot comes from the training set in place in preparation for the use of this CRSA tool in clinic to support our care planning process. The use was not as consistent as it should have been due to specific undergraduate clinic rotations with additional disruption due to COVID-19-related changes and the limitations of PreViser use related to GDPR and NHS trust requirements for patient data safety. The students appreciated its straightforward use, its help triaging patients in terms of their CRSA, and its use in allocating resources (treatments).

From the teacher perspective, the entire cumulative benefit of training and use (even limited) had an impact on our students' knowledge, competence, confidence regarding CRSA and made teaching and helping them deliver CRSA easier, although the importance of CRSA was felt to be more evident right after training.

Both the students and teachers recognise the positive effects of using PreViser as it enables the following:

- a systematic approach to CRSA.
- conversations with patients and supervisors about CRSA.

But that to have full benefit from its use, we have to work on the barriers:

- Time constraints: looking at repetition between tool (PreViser) questions and expected clinical questions.
- Use in all clinical environments, not just care planning clinics.
- Training of all staff, not just those facilitating care planning clinics.
- Training of all clinically active students, not just those involved in care planning clinics.
- Use of laminated cards in all clinical environments.
- Updated/reminders throughout the year.

The traditional 'drill and fill' mentality is still sometimes overshadowing the evidence-based minimally invasive protocols. To help prevent this, the dental curriculum from now on must reflect this preferred method of care. There is an opportunity for universities to shift away from treatment quotas, to enable students to focus more on holistic patient-centred care and reflect more on their personal development. More perseverance is needed and further emphasis during education to ensure that the students become confident clinicians in caries risk assessment and carry this into their lives as general dental practitioners.

The oral health curricula of the future must address the lack of knowledge, lack of motivation, and/or lack of confidence in CRSA not just from the students but more importantly from the teachers who should be role-modelling best practice.

We would recommend further research to understand the factors influencing student behaviour, perception, and knowledge in CRSA with the aim to make recommendations on a preferred approach and tool to help streamline CRSA education.

For your information, all abbreviations used in this manuscript are listed in Supplementary Appendix 5.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by King's College London Research Ethics Committee (ref: LRS-20/21-20542). The participants provided their written informed consent to participate in this study.

Author contributions

MN: Writing – original draft, Writing – review & editing. AH: Writing – original draft, Writing – review & editing. AC: Writing – original draft, Writing – review & editing. LC: Writing – original draft, Writing – review & editing. ZM: Writing – original draft, Writing – review & editing. LC: Writing – review & editing. AB: Writing – original draft, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article.

This study was funded by the Oral & Dental Research Trust and Fellowship award given by Oral Health Innovations Ltd (OHI Ltd), the UK supplier of PreViser technology which is a joint venture with the University of Birmingham (Previser Award 2020—RE17299). The funder OHI ltd. was not involved in the study design, collection, analysis, interpretation of data, or the decision to submit it for publication. They supported write up by providing specific information about Previser software.

Acknowledgments

The authors would like to acknowledge the contributions of specific colleagues, institutions, or agencies that aided the efforts of the authors.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/froh.2023.1290713/full#supplementary-material

References

1. Twetman S, Banerjee A. Caries risk assessment. In: Chapple I, Papapanou P, editors. *Risk assessment in oral health*. 1st ed. Springer (2020). p. 89–100. doi: 10.1007/978-3-030-38647-4_7

2. Banerjee A. "MI" inspiring future oral healthcare? *Br Dent J*. (2017) 223:133–5. doi: 10.1038/sj.bdj.2017.644

3. Martignon S, Pitts NB, Goffin G, Mazevet M, Newton JT, Douglas GVA, et al. CariesCare practice guide: consensus on evidence into practice. *Br Dent J*. (2019) 227(5):353–62. doi: 10.1038/s41415-019-0678-8

4. Heidari E, Newton JT, Banerjee A. Minimum intervention oral healthcare for people with dental phobia: a patient management pathway. *Br Dent J*. (2020) 229 (7):417–24. doi: 10.1038/s41415-020-2178-2

5. Leal SC, Damé-Teixeira N, Brito C, Kominami PA, Raposo F, Nakagawa ET, et al. Minimum intervention oral care—defining the future of caries management. *Braz Oral Res*. (2022) 36:e135. doi: 10.1590/1807-3107bor-2022.vol36.0135

6. Fontana M, Zero D. Assessing patients' caries risk. *J Am Dent Assoc*. (2006) 137 (9):1231–39. doi: 10.14219/jada.archive.2006.0380

7. GDC learning outcomes. (2023). Available online at: https://www.gdc-uk.org/docs/default-source/quality-assurance/preparing-for-practice-(revised-2015).pdf?sfvrsn=81d58c49_2 (accessed September 1, 2023).

8. "Health through Oral Wellness". Available online at: https://www/healththroughoralwellness.com (accessed Septemebr 1, 2023).

9. Kirkpatrick JD, Kirkpatrick WK. "Training evaluation: it doesn't have to be as formal as you think," training industry. (2018). Available online at: https://www.nxtbook.com/nxtbooks/trainingindustry/tiq_20180304/index.php?startid=48#/p/48 (accessed Spetember 1, 2023).

10. Firman SJ, Ramachandran R, Whelan K. Knowledge, perceptions and behaviours regarding dietary management of adults living with phenylketonuria. *J Hum Nutr Diet*. (2022) 35(6):1016–29. doi: 10.1111/jhn.13015

11. Pakdaman A, Evans RW, Howe E. Dental students' knowledge and perceptions of non-invasive dental caries management. *Aust Dent J*. (2010) 55(1):28–36. doi: 10.1111/j.1834-7819.2009.01183.x

12. Yorty JS, Walls AT, Wearden S. Caries risk assessment/treatment programs in U.S. dental schools: an eleven-year follow-up. *J Dent Edu*. (2010) 75(1):62–70. doi: 10.1002/j.0022-0337.2011.75.1.tb05023.x

13. Afsaneh P, Fatemah SS, Javad KM. Knowledge, attitude and self-reported practice of senior dental students in relation to caries risk assessment. *Oral Health Dent Manage*. (2014) 13(4):1106–11.

14. Le Clerc J, Gasqui M-A, Laforest L, Beaurain M, Ceinos R, Chemia F, et al. Knowledge and opinions of French dental students related to caries risk assessment and dental sealants (preventive and therapeutic). *Odontology*. (2020) 109:41–52. doi: 10.1007/s10266-020-00527-7

15. Calderón SH, Gilbert P, Zeff RN, Gansky SA, Featherstone JD, Weintraub JA, et al. Dental students' knowledge, attitudes, and intended behaviors regarding caries risk assessment: impact of years of education and patient age. *J Dent Edu*. (2007) 71(11):1420–70. doi: 10.1002/j.0022-0337.2007.71.11.tb04412.x

16. Doméjean S, Léger S, Simon A, Boucharel N, Holmgren C. Knowledge, opinions and practices of French general practitioners in the assessment of caries risk: results of a national survey. *Clin Oral Investig*. (2017) 21(2):653–63. doi: 10.1007/s00784-016-1932-y

17. Michie S, Atkins L, West R. The Behaviour change wheel book – a guide to designing interventions. (2014). Available online at: http://www.behaviourchangewheel.com/about-book (accessed September1, 2023).

18. Overcash JA. Narrative research: a review of methodology and relevance to clinical practice. *Crit Rev Oncol Hematol*. (2003) 48(2):179–84. doi: 10.1016/j.critrevonc.2003.04.006

19. Teich ST, Demko C, Al-Rawi W, Gutbery T. Assessment of implementation of a CAMBRA-based program in a dental school environment. *J Dent Edu*. (2013) 77(4):438–47. doi: 10.1002/j.0022-0337.2013.77.4.tb05489.x

20. Featherstone JD, Adair SM, Anderson MH, Berkowitz RJ, Bird WF, Crall JJ, et al. Caries management by risk assessment: consensus statement, April 2002. *J Calif Dent Assoc*. (2003) 31(3):257–69.

21. Featherstone JD, Doméjean-Orliaguet S, Jenson L, Wolff M, Young DA. Caries risk assessment in practice for age 6 through adult. *J Calif Dent Assoc*. (2007) 35(10):703–07. 710–30.

22. Ramarao S, Sathyanarayanan U. CRA Grid—a preliminary development and calibration of a paper-based objectivization of caries risk assessment in undergraduate dental education. *J Conserv Dent*. (2019) 22(2):185–90. doi: 10.4103/JCD.JCD_389_18

23. Doméjean S, Léger S, Rechmann P, White JM, Featherstone JD. How do dental students determine patients' caries risk level using the caries management by risk assessment (CAMBRA) system? *J Dent Educ*. (2015) 79(3):278–85. PMID: 25729021

24. Brons-Piche E, Eckert GJ, Fontana M. Predictive validity of a caries risk assessment model at a dental school. *J Dent Edu*. (2019) 83(2):144–50. doi: 10.21815/JDE.019.017

25. Chaffee BW, Featherstone JD. Long-term adoption of caries management by risk assessment among dental students in a university clinic. *J Dent Edu*. (2015) 79(5):539–47. doi: 10.1002/j.0022-0337.2015.79.5.tb05913.x

frontiers | Frontiers in Medicine

TYPE Curriculum, Instruction, and Pedagogy
PUBLISHED 21 February 2024
DOI 10.3389/fmed.2024.1255088

OPEN ACCESS

EDITED BY
Melanie Nasseripour,
King's College London, United Kingdom

REVIEWED BY
Samuel Gutierrez-Barreto,
National Autonomous University of Mexico, Mexico
Prattama Santoso Utomo,
Universitas Gadjah Mada, Indonesia

*CORRESPONDENCE
Fengping Jiao
✉ fpjiao@sdfmu.edu.cn

†These authors have contributed equally to this work and share first authorship

RECEIVED 08 July 2023
ACCEPTED 12 February 2024
PUBLISHED 21 February 2024

CITATION
Meng L, Liu X, Ni J, Shen P and Jiao F (2024) An investigation for the efficacy of teaching model of combining virtual simulation and real experiment for clinical microbiology examination.
Front. Med. 11:1255088.
doi: 10.3389/fmed.2024.1255088

An investigation for the efficacy of teaching model of combining virtual simulation and real experiment for clinical microbiology examination

Ling Meng†, Xia Liu†, Jing Ni, Pei Shen and Fengping Jiao*

School of Public Health, Shandong First Medical University and Shandong Academy of Medical Sciences, Jinan, Shandong Province, China

Background: As a convenient teaching tool, virtual simulation experiment technology had been widely utilized in the field of medical education. However, virtual learning could not fully replace the benefits of in-person instruction. Therefore, finding ways to integrate both methods was crucial for achieving optimal educational outcomes. The objective of this study was to compare the effectiveness of the self-built virtual simulation and design experiment combining teaching mode and the traditional experimental teaching mode in the clinical microbiology examination experiment teaching.

Methods: This study was conducted at Shandong First Medical University in China. The experimental group consisted of 100 third-year students from the grade 2020 majoring in medical examination technology, who underwent an innovative teaching model combining virtual and real experiments. The control group comprised of 100 third-year students from the grade 2019 in the same major, who received traditional experimental teaching model. In this study, we referred to grade 2020 as cohort 2020 and grade 2019 cohort 2019. The performance of both groups was assessed via experimental and theoretical testing. Meanwhile, survey questionnaires were administered to evaluate the efficacy of the innovative experimental teaching model and students' level of satisfaction with it. Cohort 2020 conducted a survey for modules 1 to 4, while cohort 2019 only conducted a survey for module 4, as detailed in the Appendix.

Results: The majority of students in the experimental group expressed satisfaction with the teaching model that combined virtual and real experiments, as evidenced by their superior performance on both experimental operational skills (87.54 ± 8.93 vs. 82.39 ± 10.55) and theoretical knowledge tests (83.65 ± 9.02 vs. 80.18 ± 8.24) compared to those in the control group.

Conclusion: The combination of virtual simulation experiment and design experiment in the microbiological examination of clinical specimens represented an effective pedagogical approach. The instructional approach had the potential to incite a passion for learning, enhance proficiency in standardized experimental techniques, foster the ability to integrate theory with practice, and cultivate clinical reasoning skills.

KEYWORDS

virtual simulation, clinical microbiology examination, experimental teaching model, clinical thinking, experimental skill

1 Introduction

Clinical microbiology examination was a specialized course for students majoring in medical examination technology that primarily focused on the biological characteristics of pathogenic *microorganisms* and methods for microbial examination (1, 2). The theoretical knowledge of this course provided the necessary evidence for the diagnosis of diseases associated with microbial infections, which was important for detecting pathogenic microorganisms using standardized experimental techniques (3). However, challenges existed in the course. Firstly, students had insufficient time to practice and consolidate their learning from the class due to limited hours allocated for practical sessions. Secondly, the traditional experimental teaching approach was primarily focused on verification experiments, which posed a challenge for students to effectively integrate theory with practice and enhance their practical skills. Thirdly, the biosafety regulations of the laboratory made it impossible to detect pathogenic *microorganisms*, which restricted students' ability to detect such *microorganisms*.

It was acknowledged that virtual simulation technology was a convenient and effective tool. The virtual simulation experiment was designed to meet the objectives of experimental teaching and replicate real-world experimental environments (4, 5). Students engaged in immersive and realistic virtual experiments through human-computer interaction, and acquired necessary skills for independent practice when learners responded in what they perceived as realistic (6, 7).

However, the virtual simulation technology had the limitation that it could not be operated in real experiment (8). Therefore, it was of paramount importance to integrate virtual simulation experiments with actual ones and fully leverage the benefits of the former (9–11). The substitution of virtual for real could compensate for experiments that could not be conducted due to biosafety concerns or other reasons, while combining both approaches could effectively broaden and deepen experimental teaching.

This study aimed to compare the effectiveness of the self-built virtual simulation and design experiment combining teaching mode and the traditional experimental teaching mode in the clinical microbiology examination experiment teaching.

2 Research methods

2.1 Object of study

The study received approval from the Research and Ethics Committee of Shandong First Medical University. 100 third-year students enrolled in 2019 majoring in medical examination technology served as the control group and received conventional teaching methods without virtual simulation experimental platform training, offline discussion, and design experiment for microbiological examination of clinical specimens. The experimental group consisted of 100 third-year students enrolled in 2020 majoring in medical examination technology received these additional training methods named "the integration of virtual and reality ". To provide equal opportunity for both control and experimental groups with both learning opportunities, the virtual simulation experiment website was published to guide the students of cohort 2019 to carry out virtual simulation experiment after collecting the data for this study. In addition, offline discussion and design experiment were given in spare time.

2.2 Teaching strategies

The experimental instructional design consisted of two parts of virtual simulation experiment operation and real experiment, as illustrated in Figure 1. Both groups received theoretical and experimental training from the same teacher, respectively.

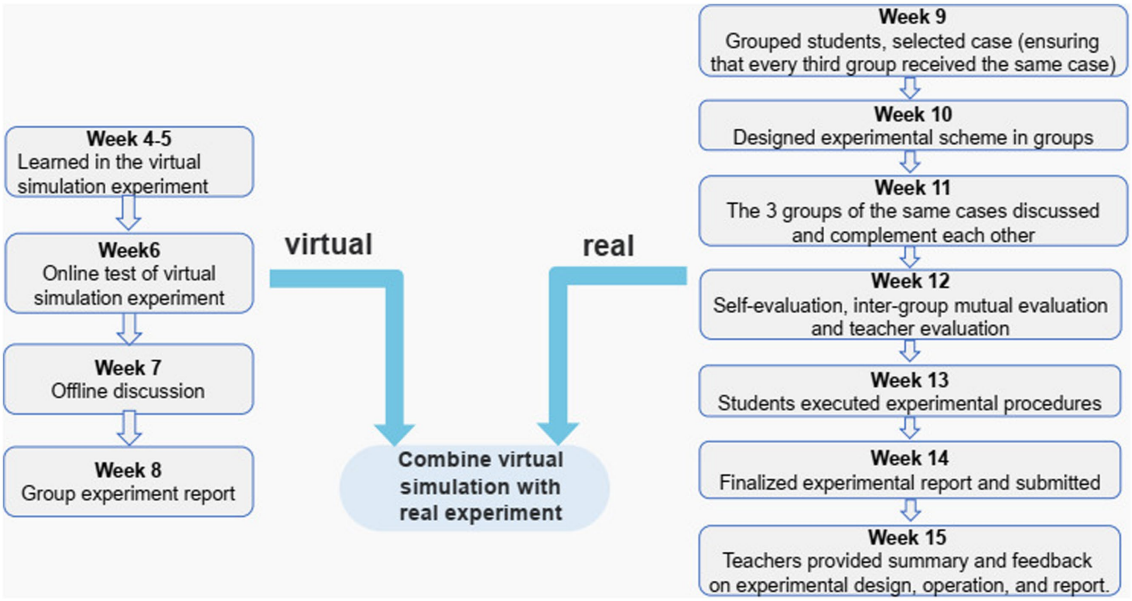

FIGURE 1
Flow chart of the teaching model of combining virtual simulation and real experiment.

2.2.1 Virtual simulation experiment operation

2.2.1.1 Construction of the virtual simulation experiment

An innovative virtual simulation experiment named "Detection of *Vibrio cholerae*" was developed based on current challenges in experimental teaching of clinical microbiology examination. This virtual simulation covered the clinical significance, laboratory detection and results of *Vibrio cholerae*. The laboratory detection was comprised of 13 microbiology test experiments, including morphological examination, isolation culture, biochemical reaction, drug sensitivity testing and serological testing of bacteria. It covered nearly all the experimental operation method of the course. More importantly, the experimental operation method of the self-created virtual simulation experiment was standardized and scientific, which effectively enhanced students' proficiency in conducting standardized microbiological experiments.

2.2.1.2 Design concept of self-created virtual simulation experiment

The diagnosis and treatment process of cholera patients was taken as the main focus throughout the entire virtual simulation experiment. It simulated the microbiology diagnostic working process from specimen reception and processing to laboratory examination, result report, and emergency treatment of cholera patients in a clinical laboratory, which closely integrated experimental teaching with clinical practice to cultivate students' clinical thinking. The interest in learning of student could be enhanced by presenting a doctor-patient dialogue that covered the symptoms, prevention and prognosis, as well as emergency treatment of cholera and the integration of the theory and practice. Additionally, an animated presentation on the classification, transmission route, pathogenic mechanism and clinical manifestations of *Vibrio cholerae* provided a multi-dimensional stimulation for students to achieve better learning outcomes.

2.2.1.3 Learning process of virtual simulation experiment

Students logged in the virtual simulation experiment using their individual login credentials, where they were introduced to the clinical significance of Cholera before proceeding to engage with two distinct modules: "guidance" and "assessment." The former provided a detailed breakdown of each experimental step, allowing beginners to follow along and learn through practical application. Students could move on to the latter module and conduct their own assessments after getting comfortable with the process. The system evaluated students' operational proficiency to assess their learning outcomes. The "guidance" and "assessment" modules could be interchanged and repeated until all knowledge points were fully grasped. The result-oriented teaching approach were promoted to encourage student to learn actively.

2.2.1.4 The learning arrangement of virtual simulation experiment

Students were instructed to commence the virtual simulation experiment during the fourth week of instruction, followed by an online assessment in teaching week 6. In teaching week 7, teachers and students jointly participated in offline case discussions regarding *Vibrio cholerae* identification. In teaching week 8, students completed group-experimental reports on *Vibrio cholerae* identification, which systematically honed their clinical thinking skills. In teaching week 9, the teacher corrected the experiment reports and gave feedback to students.

2.2.2 Design experiment for microbiological examination of clinical specimens

2.2.2.1 Collect clinical cases and prepare specimens

The three clinical cases were presented in Table 1, and simulated clinical specimens had been prepared beforehand.

2.2.2.2 Organize students into groups

The 100 students were divided into three laboratories, with each lab consisting of nine groups with three to four students. The cases were randomly selected and evenly distributed among the groups, ensuring that every third group received the same case. Each laboratory was staffed by a trained teacher for guided laboratory operations, all of whom followed the same teaching program.

2.2.2.3 Conduct experimental design

According to the selected cases, students were grouped to complete the experimental program design for pathogenic *microorganisms*' detection of clinical specimens during the 10th teaching week. One week later, the 3 student groups were assigned to the same case discussed and complement each other, reached a consensus, and improved and perfected experimental program design, then all perfected experimental program designs were submitted to the Chinese University MOOC platform. In the 12th teaching week, the group self-evaluation, inter-group mutual evaluation (according to the scoring scale) and teacher evaluation were completed online within 3 days, and on days 4–5, teachers provided feedback on the experimental program

TABLE 1 The case information for clinical specimen design experiment.

Case number	Case information
Case 1	The patient, a 55-year-old male, was admitted with high fever and chills. He presented sudden onset of chest pain and purulent sputum. The result of X-rays revealed that he suffers from the necrotizing pneumonia. His general condition was poor, likely due to the diagnosis of diabetes before 10 years. Sputum samples were collected for microbiological examination.
Case 2	The patient, a 61-year-old female, was admitted to the hospital presenting with cough, phlegm and wheezing. Symptoms had a slow onset with marked morning cough producing frothy or serous sputum that appeared bluish-green in color. The general condition of the patient was poor with coarse breath sounds and feverishness. Sputum samples were collected for microbiological examination.
Case 3	The patient, a 14-year-old male, was admitted with symptoms of abdominal pain and fever characterized by the sudden onset, persistent severity, rotation, deep breathing exacerbation upon coughing. Tenderness and rebound pain were observed in the right lower abdomen. Abdominal puncture yielded mixed blood fluid for etiological examination.

designs, and on days 6–7, students made improvements based on this feedback and resubmitted their work online.

2.2.2.4 Perform experimental operation

In the 13th week of instruction, students executed experimental procedures based on the aforementioned improved design programs and completed pathogenic *microorganisms*' detection in simulated clinical specimens. The instructor provided appropriate guidance.

2.2.2.5 Write the experimental report

In the 14th teaching week, the experimental report must be finalized and submitted online. During the 15th week, group self-evaluation, inter-group mutual evaluation and teacher evaluation based on the rating scale were completed.

2.2.2.6 Summary and feedback

In the 15th teaching week, teachers provided a summary and feedback on experimental program design, operation, and experimental report.

3 Student assessment

Student assessment comprised laboratory test, theoretical test, and questionnaires administered after the teaching. The laboratory test aimed to evaluate students' proficiency in experimental techniques such as gram staining, oxidase testing, and catalase testing. The theoretical test was conducted in a closed-book format that assessed basic theoretical knowledge and clinical case analysis ability. The small program named Questionnaire Star was used for questionnaire survey.

3.1 Statistical analysis

The experimental and theoretical test scores of both the control and experimental groups were inputted into SPSS 25.0 software (SPSS Inc., Chicago, Illinois, United States). The data was presented as means ± standard deviations. Independent t-test was used for continuous variables such as age and test scores. Chi-square test was employed for categorical variables such as sex (male/female). A significance level of $p < 0.05$ was utilized.

4 Results

4.1 Comparison of course grades between the two groups

The 100 third-year students from the cohort 2020 majoring in medical examination technology were assigned to the experimental group, and 100 third-year students from the cohort 2019 majoring in medical examination technology were assigned to the control group. The two groups were comparable in terms of age and sex distribution (Table 2). Results of course grades showed that students in the experimental group outperformed those in the control group on both practical skills test (87.54 ± 8.93 vs. 82.39 ± 10.55) and theoretical test (83.65 ± 9.02 vs. 80.18 ± 8.24) at the end of the term, as presented in Table 3.

4.2 Questionnaire results of virtual simulation experiment in experimental group

At the end of the term, one hundred questionnaires regarding virtual simulation experiment were distributed to students in the experimental group. All questionnaires were retrieved, resulting in a 100% recovery rate (Table 4). The result of the questionnaire survey indicated that our self-created virtual simulation experiment for *Vibrio cholerae* detection had provided a highly effective learning experience. The survey results showed that 90% of students thought that the virtual simulation experiment was easy to understand, and approximately 78% of students acknowledged that the navigation and instructions offered by the program facilitated their understanding. Additionally, the survey results displayed that 90% of students praised the video and audio quality of this virtual simulation experiment. The results also turned out that 92% of the students perceived virtual simulation experimental examination as more equitable and objective than traditional experimental examinations, and almost 89% of students believed that virtual simulations were beneficial for both practical operation learning and theoretical knowledge consolidation. Furthermore, results of the survey revealed that 75% of the students felt that virtual simulations provided a lifelike experience with better time management, and they also reported feeling actively engaged in the process. In the end, about 85% of the students expressed satisfaction with the virtual simulation experiment.

4.3 Questionnaire results of a design experiment for microbiological examination of clinical specimens in experimental group

In the same way, the design experiment questionnaire for microbiological examination of clinical specimens in the experimental group was completed with a 100% recovery rate, similarly as shown in Table 5. The survey results indicated that 85% of the students were able to complete their team tasks within the given timeframe, and approximately 78% of the students believed that timely feedback from both group members and teachers was beneficial in enhancing their learning experience. Furthermore, there were 81% of the students reported an increase in interest towards learning as a result of the participation in the experiment. Moreover, survey results displayed that 89% of the students noted that all team members actively participated during the experiment. Finally, up to 90% of the students expressed pride in independently completing pathogenic *microorganisms*' detection on clinical specimens.

4.4 Questionnaire results of virtual and real experiment combined teaching method in experimental group

Table 6 presented the results of a questionnaire assessing the effectiveness of the combination virtual and real experiments in teaching Clinical Microbiology Examination. The majority (90%) of students expressed satisfaction with the learning resources provided by virtual simulation experiments and clinical specimen examinations, while 84% agreed that the combination of such

TABLE 2 The basic information of students in experimental cohort 2020 and control cohort 2019.

		Experimental group ($n = 100$)	Control group ($n = 100$)	t/χ^2 -value	p -value
	Age	21.07 ± 1.35	21.31 ± 1.29	1.285	0.200
	Sex				
	Female [n (%)]	64 (64.0)	61 (61.0)		
	Male [n (%)]	36 (36.0)	39 (39.0)	0.192	0.661

TABLE 3 Comparison of the course grades of theoretical test and experimental skills test between students in experimental cohort 2020 and control cohort 2019.

	Experimental group ($n = 100$)	Control group ($n = 100$)	t value	p value
theoretical test	83.65 ± 9.02	80.18 ± 8.24	2.840	0.005
experiment skills test	87.54 ± 8.93	82.39 ± 10.55	3.726	<0.001

TABLE 4 Results of a questionnaire on the learning experience in virtual simulation experiments of the students in experimental cohort 2020.

Question	Agree n (%)	Fall in between n (%)	Disagree n (%)
1. The virtual simulation experiment proved to be user-friendly.	90	2	8
2. The navigation of the virtual simulation experiment was simple and clear.	78	13	9
3. It is easy to learn the virtual simulation experiment according to the provided instructions.	78	15	7
4. The virtual simulation experiment boasted exceptional video and audio quality.	90	10	0
5. The evaluation of virtual simulation is more equitable and objective compared to traditional experimental assessment.	92	7	1
6. The virtual simulation experiment was a valuable tool for enhancing practical skills and reinforcing theoretical knowledge in experimental operations.	89	9	2
7. The virtual simulation experiment provided a lifelike experience.	75	20	5
8. The management of time could be optimized through virtual simulation experiments.	75	18	7
9. I was more actively engaged in the virtual simulation experiment compared to the traditional experimental classes.	70	25	5
10. I was completely satisfied with virtual simulation experiment.	85	15	0

TABLE 5 Results of a questionnaire for a design experiment of the microbiological examination of clinical specimens of experimental cohort 2020.

Question	Agree n (%)	Fall in between n (%)	Disagree n (%)
1. Could you complete your team tasks on time?	85 (85.0)	10 (10.0)	5 (5.0)
2. Had your group members and teachers provided timely and effective feedback to enhance your learning experience?	78 (78.0)	12 (12.0)	10 (10.0)
3. Would this experiment enhance your learning motivation?	81 (81.0)	16 (16.0)	3 (3.0)
4. Did the participants in your group actively participate in the experiment?	89 (89.0)	9 (9.0)	2 (2.0)
5.Were you proud of independently completing the detection of pathogenic *microorganisms* in clinical specimens?	90 (90.0)	8 (8.0)	2 (2.0)
6.Would this experiment acquaint you with the workflow of the clinical microbiology laboratory?	90 (90.0)	7 (7.0)	3 (3.0)

simulation and offline discussion facilitated the completion of microbiological examinations. Additionally, there were 78% of the students were satisfied with the experimental design scheme that integrated virtual simulation and microbiological examination of clinical specimens. More importantly, the results showed that 89% of the students believed that this combination facilitated their understanding of microbiological testing concepts for clinical specimens, enhanced their clinical thinking abilities, and proved to be an effective teaching method in Clinical Microbiology Examination.

TABLE 6 Questionnaire results of virtual and real experiment combined teaching method of experimental cohort 2020.

Question	Agree *n* (%)	Fall in between *n* (%)	Disagree *n* (%)
1.Were the learning resources provided by the virtual simulation experiment and microbiological examination of clinical specimens satisfactory to you?	90 (90.0)	5 (5.0)	5 (5.0)
2. Did the utilization of virtual simulation experiment and offline discussion contribute to the successful completion of microbiological examination on clinical specimens?	84 (84.0)	12 (12.0)	4 (4.0)
3. Were you satisfied with the experimental teaching approach that integrated virtual simulation and microbiological examination of clinical specimens?	78 (78.0)	16 (16.0)	6 (6.0)
4. Did virtual simulation and microbiological examination of clinical specimens help you understand the ideas for microbiological testing of clinical specimens?	89 (89.0)	9 (9.0)	2 (2.0)
5. Did you agree that the teaching method of virtual and real experiment combined can improve clinical thinking and the ability to combine theory with practice?	89 (89.0)	7 (7.0)	4 (4.0)
6. Did you think that the combine of virtual and real experiment is an effective teaching method in clinical microbiology examination?	89 (89.0)	10 (10.0)	1 (1.0)

4.5 Questionnaire results of learning effectiveness satisfaction levels of two student groups

Table 7 presented the results of a questionnaire on learning effectiveness satisfaction levels of two student groups. A total of 200 questionnaires were distributed and returned, resulting in a 100% response rate. The survey findings indicated that the experimental group reported higher levels of satisfaction than the control group with respect to "keen interest in learning," "rudimentary knowledge acquisition," "standardized experimental techniques," "development of clinical thinking skills," "integration of theory and practice," "self-directed learning improvement," and "strengthening communication skills," the difference was statistically significant ($p < 0.05$).

5 Discussion

In this study, the efficacy of teaching model of combining virtual simulation and real experiment for Clinical Microbiology Examination were studied. During the experiment, students in the experimental group performed a "the integration of virtual and reality "and online discussions, while the control group received only traditional teaching methods without above training. The questionnaires covered four aspects: the learning experience in virtual simulation experiment and a design experiment of the microbiological examination of clinical specimens, the effectiveness of virtual and real experiment combined teaching method, learning effectiveness satisfaction levels. And results were collected and analyzed. Results showed that experimental group students had higher scores in both practical skills test and theoretical test than the control. It indicated that the innovative "the integration of virtual and reality "improved students' mastery of knowledge and skills. The survey results also reported that approximately 85 and 90% of the students expressed satisfaction with the virtual simulation experiment and the design experiment for microbiological examination of clinical specimens, respectively. More importantly, about 89% of the students believed that "the integration of virtual and reality "were helpful to the understanding and learning of the clinical microbiology examination. Above results could be attributed to the repetitive training provided by virtual simulation and students' interests in design experiment (12–15). As virtual simulation could be considered for just-in-time training before exposure to traditional lab activities, for specific skill acquisition using deliberate practice (16, 17). Therefore, by integrating virtual and realistic experiments, the professional skills mastered by learners in the virtual simulation environment could be applied to specific practice, which could effectively improve the understanding of knowledge. Results from the learning effectiveness satisfaction survey on two groups of students showed that compared to the control group, the experimental group exhibited stronger learning motivation, higher professional competence, and enhanced clinical thinking ability as well as improved capacity in integrating theory with practice. These findings aligned with prior research highlighting higher student satisfaction with virtual simulations (18, 19).

Compared with previous studies (19–22), our approach incorporated offline discussion on the basis of virtual simulation, and more importantly, combined virtual simulation with real experiment. The microbiological detection experiment of clinical specimens was carried out after further sorting out the knowledge, skills learned from the virtual simulation experiment and clinical thinking of microbial detection through offline discussions, which enabled the conversion of theory into practice and solved the problem of converting virtual simulation into actual operation to a certain extent. However, there were limitations in this study. First, because there was only one teaching class of medical examination technology majored in our school each year, the control group in this study could only use the learning data of cohort 2019 students to conduct quasi-experimental research, rather than experimental research, which might cause some bias in the results. Second, the teaching reform had only been tried in one teaching class and needed to be carried out several more times to collect more data to ensure the reliability of the results.

In summary, this study adopted a results-oriented approach to address teaching challenges and enhance students' learning abilities. By integrating virtual and real experiments and leveraging their respective advantages, it motivated learners, improved proficiency in standardized experimental techniques, fostered the integration of theory with practice, and cultivated clinical reasoning skills. Therefore, the pedagogical framework of combining virtual and real methods was highly effective, and it was worth popularizing and applying in

TABLE 7 The comparisons of the learning effectiveness satisfaction levels of experimental cohort 2020 and control cohort 2019.

Question	Experimental group *n* (%)	Control group n (%)	χ^2 -value	*p*-value
1. You demonstrated a keen interest in acquiring knowledge.	75 (75.0)	54 (54.0)	9.630	0.002
2. You grasped rudimentary knowledge of this course.	78 (78.0)	50 (50.0)	17.014	<0.001
3. Your technique for conducting experiments was executed in a standard manner.	85 (85.0)	61 (61.0)	14.612	<0.001
4. You had developed a certain level of clinical thinking.	77 (77.0)	46 (46.0)	20.294	<0.001
5. You had the ability to integrate theory with experiment.	77 (77.0)	46 (46.0)	20.294	<0.001
6. You improved your self-directed learning abilities.	81 (81.0)	63 (63.0)	8.036	0.005
7. You had enhanced your proficiency in communication.	80 (75.0)	45 (45.0)	26.133	<0.001

similar courses. In the future, studies would be conducted on the attention of a single variable, such as designing experiments to explore which of the influencing factors plays a major role.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by the Research and Ethics Committee of Shandong First Medical University (R202203010089). Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

LM: Investigation, Methodology, Supervision, Validation, Visualization, Writing – review & editing. XL: Data curation, Investigation, Supervision, Validation, Visualization, Writing – review & editing. JN: Data curation, Software, Supervision, Validation, Writing – review & editing. PS: Data curation, Software, Supervision, Validation, Writing – review & editing. FJ: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Project administration, Resources, Supervision, Validation, Writing – original draft, Writing – review & editing.

Funding

This work was supported by Shandong Province undergraduate teaching reform project (M2022149), Shandong First Medical University teaching reform project (2021XY124, XZ2022010).

Acknowledgments

The authors thanked all the students who participated in the study.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmed.2024.1255088/full#supplementary-material

References

1. Joshi LT. Using alternative teaching and learning approaches to deliver clinical microbiology during the COVID-19 pandemic. *FEMS Microbiol Lett.* (2021) 368:fnab103. doi: 10.1093/femsle/fnab103

2. Blondeau J. Clinical microbiology laboratories and COVID-19: an interview with Joseph Blondeau. *Future Microbiol.* (2021) 16:615–8. doi: 10.2217/fmb-2021-0113

3. Stevens NT, Holmes K, Grainger RJ, Connolly R, Prior AR, Fitzpatrick F, et al. Can e-learning improve the performance of undergraduate medical students in clinical microbiology examinations. *BMC Med Educ.* (2019) 19:1–8. doi: 10.1186/s12909-019-1843-0

4. Liu Y, Li S, Guo JR, Chai G, Cao C. The application of virtual reality technology in sports psychology: theory, practice, and prospect. *Comput Intell Neurosci.* (2022) 2022:5941395. doi: 10.1155/2022/5941395

5. Orland MD, Patetta MJ, Wieser M, Kayupov E, Gonzalez MH. Does virtual reality improve procedural completion and accuracy in an intramedullary Tibial nail procedure? A randomized control trial. *Clin Orthop Relat Res.* (2020) 478:2170–7. doi: 10.1097/CORR.0000000000001362

6. Tyler R, Danilova G, Kruse S, Pierce A. Innovations through virtual reality simulation. *Mo Med.* (2021) 118:422–5.

7. Linganna RE, Starks VB, Weiss SJ, Feinman JW, Augoustides JG, Patel SJ. Mid-Atlantic cardiac anesthesiology-leveraging virtual technology to advance continuing medical education. *J Cardiothorac Vasc Anesth*. (2022) 36:2259–61. doi: 10.1053/j.jvca.2022.03.041

8. Wu Q, Wang Y, Lu L, Chen Y, Long H, Wang J. Virtual simulation in undergraduate medical education: a scoping review of recent practice. *Front Med*. (2022) 9:855403. doi: 10.3389/fmed.2022.855403

9. Liu Y, Hu Y, Zhang S, Huang S, Li J, Yan L, et al. Virtual-real combination Ritchey-common interferometry. *Opt Express*. (2022) 30:15777–95. doi: 10.1364/OE.457704

10. Abdel Haleem SEA, Ahmed AA, El Bingawi H, Elswhimy A. Medical Students' perception of virtual simulation-based learning in pharmacology. *Cureus*. (2023) 15:e33261. doi: 10.7759/cureus.33261

11. Mariani AW, Pêgo-Fernandes PM. Medical education: simulation and virtual reality. *São Paulo Med J*. (2011) 129:369–70. doi: 10.1590/s1516-31802011000600001

12. Pottle J. Virtual reality and the transformation of medical education. *Future Healthc J*. (2019) 6:181–5. doi: 10.7861/fhj.2019-0036

13. Edgar AK, Macfarlane S, Kiddell EJ, Armitage JA, Wood-Bradley RJ. The perceived value and impact of virtual simulation-based education on students' learning: a mixed methods study. *BMC Med Educ*. (2022) 22:823. doi: 10.1186/s12909-022-03912-8

14. Zhao J, Lu Y, Zhou F, Mao R, Fei F. Systematic bibliometric analysis of research hotspots and trends on the application of virtual reality in nursing. *Front Public Health*. (2022) 10:906715. doi: 10.3389/fpubh.2022.906715

15. Ding Y, Shen W, Yang J, Yan H, Wang L, Zhang X. Application of problem-based self-designed experiments in physiology laboratory teaching. *Adv Physiol Educ*. (2023) 47:243–50. doi: 10.1152/advan.00196.2022

16. Sadeghi H, Jehu DA, Daneshjoo A, Shakoor E, Razeghi M, Amani A, et al. Effects of 8 weeks of balance training, virtual reality training, and combined exercise on lower limb muscle strength, balance, and functional mobility among older men: a randomized controlled trial. *Sports Health*. (2021) 13:606–12. doi: 10.1177/1941738120986803

17. Romand M, Dugas D, Gaudet-Blavignac C, Rochat J, Lovis C. Mixed and augmented reality tools in the medical anatomy curriculum. *Stud Health Technol Inform*. (2020) 16:322–6. doi: 10.3233/SHTI200175

18. Welk A, Maggio M, Simon J, Scarbecz M, Harrison J, Wicks R, et al. Computer-assisted learning and simulation lab with 40 dentSim units. *Int J Comput Dent*. (2008) 11:17–40.

19. Meysam SM, Seyyed MA, Fakhrosadat M, et al. A study to investigate the efectiveness of the application of virtual reality technology in dental education[J]. *BMC Med Educ*. (2022) 22:457. doi: 10.1186/s12909-022-03543-z

20. Al-Nakhle H. The effectiveness of scenario-based virtual laboratory simulations to improve learning outcomes and scientific report writing skills. *PLoS One*. (2022) 17:e0277359. doi: 10.1371/journal.pone.0277359

21. Makransky G, Bonde MT, Wulff JS, Wandall J, Hood M, Creed PA, et al. Simulation based virtual learning environment in medical genetics counseling: an example of bridging the gap between theory and practice in medical education. *BMC Med Educ*. (2016) 16:98. doi: 10.1186/s12909-016-0620-6

22. Sankaranarayanan G, Parker L, De S, Kapadia M, Fichera A. Simulation for colorectal surgery. *J Laparoendosc Adv Surg Tech A*. (2021) 31:566–9. doi: 10.1089/lap.2021.0096

frontiers | Frontiers in Oral Health

TYPE Original Research
PUBLISHED 11 March 2024
DOI 10.3389/froh.2024.1306421

OPEN ACCESS

EDITED BY
Jorma I. Virtanen,
University of Bergen, Norway

REVIEWED BY
Mohammad Khami,
Tehran University of Medical Sciences, Iran
Ozan Karaca,
Ege University, Türkiye

*CORRESPONDENCE
Melanie Nasseripour
melanie.nasseripour@kcl.ac.uk

RECEIVED 03 October 2023
ACCEPTED 13 February 2024
PUBLISHED 11 March 2024

CITATION
Nasseripour M, Angelova Volponi A, Rajadurai S, Turner J, Dahir Hassan M, Bartlett A and San Diego J (2024) Clinical experiences of staff and students in transitioning from in-person to blended teaching.
Front. Oral. Health 5:1306421.
doi: 10.3389/froh.2024.1306421

Clinical experiences of staff and students in transitioning from in-person to blended teaching

Melanie Nasseripour[1]*, Ana Angelova Volponi[1], Susha Rajadurai[1], Jonathan Turner[1], Muna Dahir Hassan[2], Anitha Bartlett[1] and Jonathan San Diego[1]

[1]Centre for Dental Education, Faculty of Dentistry, Oral and Cranio-Facial Sciences, King's College London, London, United Kingdom, [2]Faculty of Nursing, Midwifery & Palliative Care, King's College London, London, United Kingdom

This paper describes some of the lessons learned during the COVID-19 pandemic from a study conducted with a group of clinical teachers and undergraduate dental students at the Faculty of Dentistry, Oral & Craniofacial Sciences (FoDOCS) at King's College London about the use of a combination of remote, online and in-person teaching methods that resumed from June 2020. In the narrative research, participants shared their experiences delivering online clinical workshops and their previous experiences delivering face-to-face sessions online, both during and before the pandemic. We conducted remote interviews with the participants via video conferencing, which were recorded, transcribed, and analysed using thematic analysis. Narrative accounts revealed commonalities organised into seven themes, highlighting some of the challenges encountered during the pandemic and providing insights into addressing different curricular constraints and concerns when utilising various delivery modes during emergency situations, such as pandemics. In our study, we concluded that students and teachers benefit from dissociating clinical learning from clinical treatment sessions to focus on the educational intent and content before applying them chairside with patients. Throughout the course, students and teachers were challenged by a lack of engagement. In addition, it is important to examine the online fatigue highlighted by both students and teachers and identify ways to improve time, literacy, and facilitation to create a more conducive learning environment.

KEYWORDS

blended learning, narrative research, thematic analysis, online learning, teaching modalities, clinical teaching

1 Introduction and background

During the pandemic, higher education institutions embraced innovative pedagogical approaches that involved technology-enhanced learning (TEL). Blended learning (a combination of in-person and online learning) became part of mainstream teaching and learning as it supports the use of TEL in teaching session activities involving training, presentations, and discussion groups in both synchronous and asynchronous modes (1). Alammary (2) suggested five components of blended learning, which combine face-to-face (1) teacher-led instructions and (2) collaboration among students on specific learning activities with online (3) teacher-supervised instructions, (4) collaborative

student work in an online environment, and (5) unsupervised self-paced student activities. Several factors influence the effectiveness of blended learning approaches (1–3). Some of the factors are categorised based on their relation to students, teachers, and technologies (3).

Blended learning has its strengths and limitations. Several studies suggest that blended learning positively affects the learning process, assessment, and outcomes (1–4). However, during the pandemic, the hybrid mode of in-person and online teaching and learning introduced challenges, barriers, and limitations (5, 6). Blended learning can provide students with more flexibility in accessing and interacting with learning materials, allowing them to learn at their own pace. However, the lack of face-to-face interaction can make it difficult for teachers to provide personalised feedback and guidance to students, which can lead to a lack of engagement and motivation. In addition, the difficulty of managing and monitoring online activities of students can present a challenge for teachers.

Narrative accounts from students and staff can provide insight into the lessons learned from introducing blended learning during the COVID-19 pandemic. A number of dental institutions, like other disciplines in higher education, were compelled to adopt and establish online delivery of education. Providing in-person training, in-person learning, and supervised teaching in clinical settings is a well-established pedagogical approach that has long been in place. Therefore, the sudden emergence of a pandemic presented a significant challenge for dental education institutions.

Undergraduate clinical students attending clinical courses and training at our Faculty of Dentistry, Oral & Craniofacial Sciences (FoDOCS) at King's College London did not experience prolonged periods of remote teaching and training.

The teaching and learning activities, which ran within the clinical teaching sessions and their impact on the quality of learning outcomes achieved, encompassed:

- Synchronous discussions in person and online clinical case-based scenarios.
- Asynchronous discussions on posting clinical specific questions facilitated by clinical teachers to moderate the discussion/postings from students.
- Synchronous video conferencing seminars centred around a specific clinical case scenario, with breakout sessions for students to look at the case together and be back in the seminar, followed by moderate discussions with clinical teachers present.

Moreover, staff and students alike have experienced challenges in transforming teaching into a blended mode during the pandemic. Given the constraints of safe distancing and the changing traditional teaching practices to the online environment, clinical teachers had to provide clinical care to patients while also training students.

In response to finding an alternative to our teacher-centred (face-to-face) clinical education model and ensuring continuous development of clinical knowledge, reasoning, and skills, we explored alternative teaching approaches. Learning and teaching resources in the virtual learning environment (VLE) were rapidly redesigned, and video conferencing tools were adopted and applied in teaching clinical sessions for the clinical training and teaching of undergraduate dental students. Online bulletin boards were used to post clinical scenarios on asynchronous forums with polling, informed by problem-based learning. This platform enabled students to learn, discuss, and debate with peers online regarding the management of a clinical problem using the latest evidence facilitated by clinical teachers.

Facilitated synchronous communications in debrief seminars were conducted via MS Teams meeting chat rooms (e.g., problem-based learning chat rooms).

Narrated PowerPoint lectures, lecture capture videos, and recordings of the debrief seminars were made available for access 24 h a day.

The purpose of the present paper was to examine the clinical teaching practices involved in blended learning by analysing student and teacher narratives. Narrative research [see (7)] was conducted to investigate the lived experiences of a small group of teachers and students engaged in blended, in-person, and remote teaching practices.

2 Methods

The research aims to explore and provide insight into the lived experience of students and staff at FoDOCS during the Covid-19 pandemic, especially regarding the rapid introduction and implementation of technology-enhanced learning.

The study has been approved by the KCL Research Ethics Committee (LRS-20/21-20813, PNM Research Ethics Panel).

2.1 Researchers, participants, and settings

The staff participants were recruited via purposive sampling from the group of clinical teachers who teach in our Undergraduate Integrated Clinical Care clinics in the restorative disciplines. These teachers have been involved in delivering online clinically themed workshops and had previous experience delivering these face-to-face sessions. Student participants comprised undergraduate Year 4 (BDS4) students from the 2020/21 cohort who attended the sessions online during the pandemic and had previous experience of attending clinical sessions delivered face-to-face. The strategy and approach to online delivery of clinical teaching for the BDS4 cohort was representative of the strategy adopted for all clinical teaching sessions for all clinically active dental students, i.e., BDS2/3/4/5. All participants volunteered to take part in the study. Each participant was sent a detailed study information sheet and given a minimum of 24 h to decide on participating in the study.

The FoDOCS curriculum was very specific in its approach during the pandemic, outlined as follows (Figure 1):

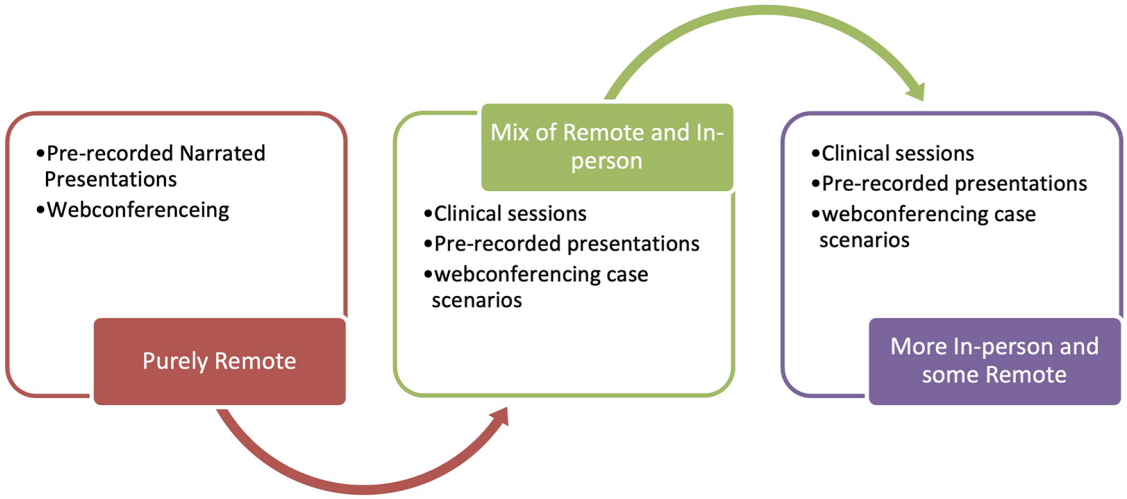

FIGURE 1
Technologies and modalities used at the Faculty of Dentistry, Oral & Craniofacial Sciences, King's College London during the pandemic: mix of remote, online, and in-person sessions.

- From March 2020 to June 2020, the dental undergraduate curriculum was delivered fully online and focused on theories relevant to familiarising and equipping students with the knowledge and skills required for different clinical situations they may encounter traditionally (purely remote).
- From June 2020, a hybrid curriculum was implemented, with some in-person clinical sessions, mainly consultant clinics and outreach patient care, as well as simulation clinics in lieu of patient care at our main teaching hospitals (a mix of remote and in-person).
- As on-campus clinical teaching and learning were prioritised for BDS5 (final-year students as they graduate within 3 or 4 months), the BDS4 cohort continued with a combination of some on-campus simulation activities and asynchronous/synchronous online teaching and learning (more in-person and some remote).

2.2 Interview and identification of narrative accounts

Participants were asked questions and prompted to narrate the events that transpired relating to the questions, as recalled by one of the researchers (Table 1). Initially, general questions were asked to gain a better understanding of their teaching experiences. These were followed by specific questions related to teaching and learning practices.

TABLE 1 Interview questions and prompts for students and teachers at the Faculty of Dentistry, Oral & Craniofacial Sciences, King's College London.

Staff (clinical educators)	Students
How do you feel about online teaching being more embedded in the curriculum? Sum up the pros and cons regarding online clinical teaching. (What went well and what did not go so well?) Do you feel that your students' clinical competency (or knowledge) has improved following the online clinical teaching sessions?	How do you feel about online teaching being more embedded in the curriculum? Sum up the pros and cons regarding online clinical teaching. (What went well and what did not go so well?) Do you feel that your clinical competency (or knowledge) has improved following the online clinical teaching sessions?
How did you experience your role as a clinical teacher during the online teaching sessions? React to the statement: "It was easy for me to interact with my students during the online clinical sessions." What are your positive and negative experiences in online clinical teaching sessions with case-based scenarios? (What went well and what did not go so well?) Do you feel the learning outcomes set in the module (programme) have been delivered? If not, can you identify the ones that were not? What has been your experience with posting of clinical specific questions on an online forum	What has been your experience with online MS Teams seminars around a specific clinical case scenario? React to the statement: "It was easy for me to interact with my teachers during the online clinical sessions." What are your positive and negative experiences in online clinical teaching sessions with case-based scenarios? (What went well and what did not go so well?). Do you feel the learning outcomes set in the module (programme) have been delivered? If not, can you identify the ones that were not? What has been your experience with posting of clinical specific questions on an online forum.
Did you feel students were engaged in the online teaching sessions? React to the statement: "During online sessions, I had more time to discuss and reflect on different clinical aspects with my students." React to the statement: "During online clinical teaching sessions, students worked more collaboratively and have boosted their team working skills."	Do you feel that you were engaged in learning during these sessions? React to the statement: "During these sessions, I had more time to discuss and reflect on different clinical aspects with my clinical teachers." React to the statement: "During online clinical teaching sessions, I worked more collaboratively and have boosted my team working skills."

Interviews were conducted by researchers who were not directly involved with teaching the students or working with the clinical teachers. The sessions were recorded, and narrative accounts were transcribed using automatic captioning. Interviewers reviewed and analysed the transcriptions. No video images were recorded. The overall process is summarised in Figure 2.

2.3 Analysing narrative accounts: thematic analysis

In analysing narrative data, thematic analysis was used to identify commonalities and differences in the ideas and phrases that students and teachers articulated in their narratives and that can indicate some degree of importance allocated to a specific thought or occurrence. This research used three aspects of identifying themes (7):

- Recurrence criterion, referring to concepts that are repeated using similar words or phrases,
- Repetition criterion, meaning that an idea is conveyed with the use of the same words,
- Forcefulness, referring to the emphasis applied to a concept.

The coding process (Figure 3) stemmed from an inductive approach, and the themes were progressively refined (data familiarisation, initial coding, and generating themes from the coding). They described the perceptions of the participants as interpreted by the researcher, who became a "storyteller who interpreting data through the lens of their own cultural membership" (8) in this context of oral health education at FoDOCS (King's College London).

Following the transcription of each interview, the transcripts were reviewed by multiple members of the research team to highlight and note the major salient themes. Narrative responses were coded and then reanalysed for commonalities, which were then used to identify the themes. The themes were communicated to the research team, and at a consensus meeting, the themes were discussed, peer-validated, and agreed upon. A coding scheme with the description was made available to two researchers calibrated to code the transcripts.

3 Results

The narrative accounts were derived from responses during the interviews, which represented lived experience of Year 4 Bachelor of Dental Surgery programme students ($n = 3$) and clinical teachers ($n = 5$) teaching in our Undergraduate Integrated Clinical Care clinics and supervising in the restorative discipline within the context and setting at King's, as presented in Section 2.1.

The implementation of a mix of fully online, hybrid, synchronous, and asynchronous facilitation of teaching presented pedagogical challenges and constraints that may impact the subjective views of the narrative. However, reflexivity in analysing the accounts considered different factors that may unavoidably be featured by the participants in presenting their experiences.

Commonalities identified in the coded narrative accounts were reanalysed and scrutinised by the research team after the

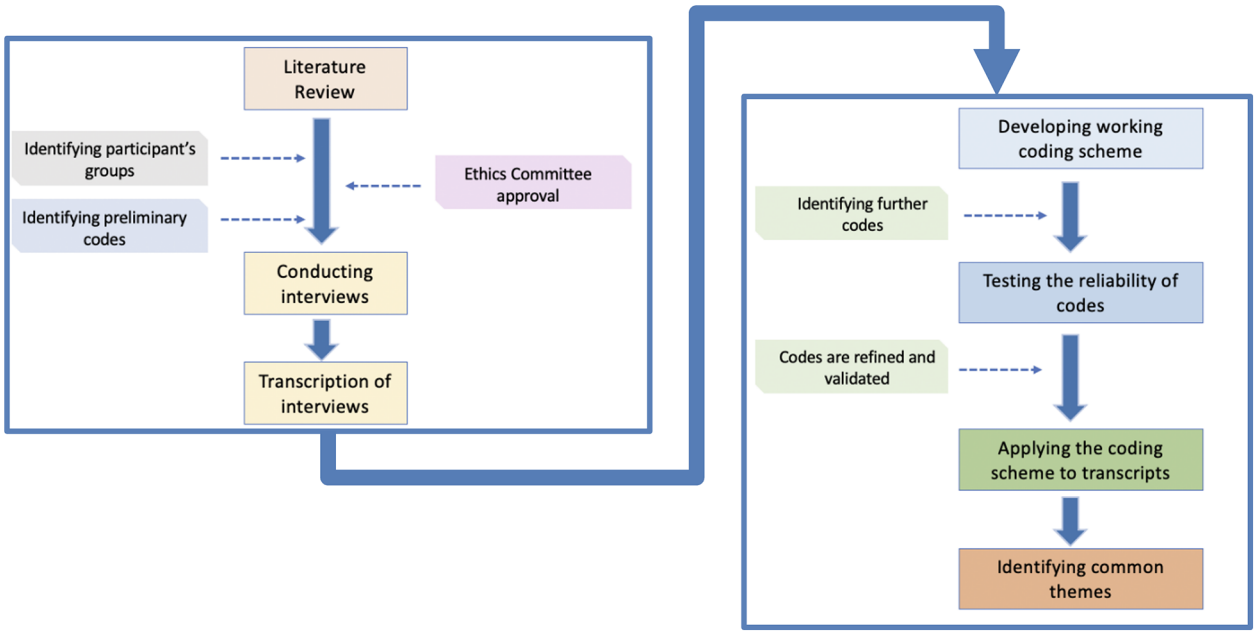

FIGURE 2
Interview conduct and analysis of narrative accounts of students and teachers at the Faculty of Dentistry, Oral & Craniofacial Sciences, King's College London.

FIGURE 3
Identified commonalities and thematic categorisation for coding of narrative responses regarding online education during the COVID-19 pandemic by a sample of students and teachers at the Faculty of Dentistry, Oral & Craniofacial Sciences, King's College London.

researchers validated the coded narrative accounts. Seven themes were agreed as the main findings.

Short descriptions of the commonalities within each of the seven themes are presented in Figure 3.

Table 2 shows examples of narrative accounts. A total of 26 sub-themes were identified, each give a distinct brief description as labels. Numeric coding is for ease of use in referring to the themes and for the purposes of researchers' coding scheme operationalisation.

4 Discussion

The pandemic has presented several pedagogical challenges and curricular constraints. Due to the large size of our student population at King's FoDOCS in the United Kingdom, our experience in providing clinical education has enabled us to offer a combination of fully online, blended, and in-person teaching within clinical settings, as well as virtual and face-to-face tutorials.

We may not be the only dental faculty to experience this. Hence, higher education institutions need to be aware of the narrative accounts that provide insight into the different practices encountered and how they were addressed. The mix of delivery modes has created new challenges for clinical teaching and learning. Based on the qualitative analysis of the seven identified themes in student and teacher lived experiences, we offer suggestions for dealing with curricular and pedagogical constraints in clinical teaching and learning. The challenges may therefore be managed more structurally, systematically, and innovatively in the event of a similar pandemic situation.

4.1 Time

The narrative highlighted Time as a theme relating to constraints on time spent in sessions, timing or timetabling, and time management. Participants relate this notion of time to the efficiency, effectiveness, and appropriateness of teaching and learning activities. For instance, several narrative comments alluded to the flexibility offered by mixed delivery methods and even opportunities that allowed for the theoretical aspects of the curriculum to be delivered online, making student rotations for clinical scheduling easy. This confirms experiences reported by other institutional and healthcare students (9). The below narrative comments somehow confirm views shared by both students and staff:

> *"They've put the teachers on a timetable so we are not consistently with a group…ended up teaching groups that… would never normally teach and wouldn't normally see on the clinic". (Teacher Participant 4)*

> *"… Definitely did have more time. … it's always busy on clinics that you don't really have that much time to discuss through a patient in full detail …. So it's a bit more relaxed, a bit more*

TABLE 2 Description of identified commonalities by themes and corresponding examples of quoted narrative responses regarding online education during the COVID-19 pandemic by a sample of students and teachers at the Faculty of Dentistry, Oral & Craniofacial Sciences, King's College London.

Theme	Descriptions of sub-theme commonalities	Example of quoted narrative responses
1	Time: maximise the use of teaching session time aligned with the teaching/learning activities	*So now we've got a pure hour to go through the tutorials* (Teacher 1)
1	Time: preparation time needed for the session to prepare teaching/learning sessions	*With online like for example with the lectures that we had a pre recorded that means that you can do them at your own pace. So you kind of control the rate of like how you'll study 'cause when we had lectures face to face it was really difficult to attend every single lecture or like don't even attend like you would go there then* (Student 2)
1	Time: allocation of time slots for the online teaching/learning sessions	*I think if you are going to embed days or even weeks of online teaching then they need to be timetabled some downtime or in-between those sessions* (Teacher 5)
1	Time: opportunity to adjust dedicated time around different commitments	*So it also gives flexibility to students and teachers* (Teacher 5)
2	Interactions: engaging in discussions of ideas and opinions	*Then I think, yeah, I think that's just because we had our cameras off so we wouldn't be as engaged because face to face, your teacher can see you. They can see what you're doing. They can see if you're talking to someone else, so you have to stay focused. UM, but online. There's no accountability. Nobody can see what you're doing so. Yeah, you can kind of lose engagement* (Student 2
2	Interactions: presence and absence of observable behaviour (cues, gestures) that conveys meaning	*They are following what you're saying by nodding their head yes. With the body language* (Teacher 5)
2	Interactions: expectation setting about the session activities required	*I told them that in advance that I've got your names, they're going to be asking you questions. And I expect you to answer. And that way it kept their attention and they knew there had to be there* (Teacher 4)
3	Facilitation: changes in the facilitation style related to the quality of discussions	*Unfortunately, it becomes a monologue in a bit like Now I'm talking to you and I can't see you…You know, it's the detached voice* (Teacher 4) *There are times when you're kind of waiting for some interactions with students, nothing is forthcoming* (Teacher 3)
3	Facilitation: changes in the facilitation style depending on the setting and mode	*You tend to find some students interact very well… but then again that was probably not dissimilar to, to face-to-face tutorial teaching. You'll find some of the students who, who give a lot back* (Teacher 3)
3	Facilitation: changes in the facilitation affected by the group size of participants	
3	Facilitation: change in facilitation affected by the quality of the teacher	*You have different teachers, different ideas, different delivery, different experience. And the thing is the main student complaint was What was being given to them was different ideas, different delivery, different experience. And the thing is the main student complaint was What was being given to them was different.* (Teacher 2)
4	Literacy: managing ICT issues/challenges	*I think are not used to teaching online. UM, so they found it quite hard to adapt at the beginning, so that impacted the learning that was provided to us kind of cause and they wouldn't be able to explain things. Online because they would want to be showing us models or like uhm. Or like a textbook paid or something, and they wouldn't know how to configure that and they wouldn't know how to share their screen either. So sometimes they had examples where they didn't know how to share screen. And so I think. I think they are trying their best, but maybe like training on technology might be useful* (Student 1)
4	Literacy: managing hardware/technical literacy	*Seminar where the IT that wouldn't connect. And now IT at King's has always been poor* (Teacher 2)
4	Literacy: managing the learning environment when lacking ICT/hardware	*I think that it was a very steep learning curve…* (Teacher 4)
5	Scenario-based: offering opportunities to become aware of unfamiliar scenarios	
5	Scenario-based: opportunities to deal with uncertainty	*No way to … connect theoretical side and say their clinical practices* (Teacher 4)
5	Scenario-based: opportunities to bridge theory and clinical practice	
5	Scenario-based: opportunities to develop teaching practice	*Now we have lectures, online on our Keats space and they're all narrated and everything, and looked at them and ever, so that's really good* (Student 1)
6	Learning outcomes: increase the production of learning resources	*We are actually generating a lot more material now, resources and updating the resource is because we're moving it online* (Teacher 1)
6	Learning outcomes: alignment between learning outcomes and sessions provided	*We've made sure that those tutorial sessions are delivering certainly what we intended before and probably more so because of where we are* (Teacher 1)
6	Learning outcomes: quality discussion about the scenarios	*Actually, go into a lot more depth with these cases.* (Teacher 1)
6	Learning outcomes: perception of meeting LOs between in-person and online clinical scenarios	
7	Psychological: activities affecting attention and fatigue in sessions	*But sometimes those classes would overrun so you would just be sitting down for three hours and it would be really hard to concentrate. So you just started to get a bit fatigued and loose your concentration faster, but I guess yeah.* (Student 2)
7	Psychological: activities affecting mental health/self-esteem	*And the biggest problem for students is asking questions. A lot of them don't want to be really ridiculed* (Teacher 2)

> *time and then you can discuss at your own pace, we definitely did have more time. (Student Participant 1)*

> *"We spent most of the time looking for student … in a very limited amounts of time. Whereas online, you know that that's what they're doing for the afternoon or morning." (Teacher Participant 4).*

Staff brought up timetabling as both a positive and negative aspect of online teaching. While some saw the online delivery as a better use of the timetable, others felt challenges in managing session scheduling. However, the accounts seemingly suggest that both students and staff were less pressured by time constraints as scheduling provided more flexibility (9). The narratives highlight the productive use of session time and fewer preparation requirements to manage clinical activities and teaching and learning activities between mixed modes of session delivery.

4.2 Interaction

Goetz et al. (10) reported that students missed contact with other students. Indeed, our students commented on the difficulty in connecting with others. Some were reluctant to ask questions, with one highlighting that teachers were unable to read body language online and see when there was confusion and another mentioning that recording the session is a disincentive to asking questions. It seems that being able to turn cameras off also promoted disengagement. Wang et al. (11) similarly reported that the interaction between teachers and students showed the lowest satisfaction in an online teaching environment:

> *"I think it's the online learning 'cause sometimes these are people that would be asking questions in class, UM, but for some reason they wouldn't online." (Student Participant 2)*

> *"the biggest problem with this online, specially recording it, people are too scared to broach their views" (Teacher Participant 2)*

> and that perhaps "*the biggest problem for students is asking questions. A lot of them don't want to be really ridiculed." (Teacher Participant 2).*

"The elephant in the room" in terms of engagement is, of course, the fact that it is one thing to sign into an online session but quite a different thing to be engaged, as Aivaz and Teodorescu (12) reported increased student distractions and multitasking within the virtual learning environment:

> *"they can check in at the beginning of the seminar, turn the camera off, go do something else and turn it back on at the end so collaboratively as they did before in the way we used to do the face-to-face session". (Teacher Participant 4).*

> *"I had two of the students that interacted. The rest they may not have as well have been there there's very little interaction." (Teacher Participant 2)*

> *"the interaction with the students is actually reduced." (Teacher Participant 2)*

> *"that's just because we had our cameras off so we wouldn't be as engaged because face-to-face, your teacher can see you. They can see what you're doing. They can see if you're talking to someone else, so you have to stay focused." (Student Participant 2)*

Even though some staff felt that on-campus (in-person) sessions allowed for a better read of the audience, with the ability to make eye contact with moving about the room and using the space, there is also an argument for considering that student behaviour was no different from that in seminar rooms, with committed students in the front row and disengaged ones in the back. Nevertheless, on-campus rooms were often not equipped for students to take notes and access the resources simultaneously during the seminar.

> *"face-to-face tutorials …… you can sort of make eye contact with those students who aren't necessarily participating" (Teacher Participant 1) and that "you can struggle sometimes actually knowing who's there … you can't see a face you can only see an initial." (Teacher Participant 1)*

> *"some students interact very well … but then again that was probably not dissimilar to face-to-face tutorial teaching." (Teacher Participant 3)*

This was in accordance with "improved accessibility" being considered as one of the benefits of online dental education, as reported by Kerkstra et al. (13). The fact that the synchronous tutorials were recorded allowed students to revisit the session at a later point, which potentially had a negative impact on attendance and engagement during a session:

> *"help that sessions are recorded because they know that people are gonna hear them later." (Student Participant 2)*

> *"So it's a bit more relaxed, a bit more time and then you can discuss at your own pace." (Student Participant 1)*

The challenge remains in an online environment to properly gauge the engagement or even the presence or absence of the students within the tutorial. This issue with students exhibiting a lack of interest and motivation, with increased issues of absenteeism and distraction during online classes, was reported by Iqbal et al. (14).

Whether in an online or on-campus setting, the challenge to connect and engage with the audience remains and is also related to the facilitator and their skills (clinical and pedagogical) in maintaining a captivated audience.

4.3 Facilitation

When looking at facilitation, we can see an intuitive link with the interaction theme, and these aspects mutually impact each other. However, here, the participants are outlining very defined issues concerning teaching and learning styles related to synchronous/asynchronous, online, and on-campus modalities:

- Smaller group sizes in the online environment appeared more conducive to group discussions, as there was a general reluctance from many students to ask questions. This observation is also reported by Kaczmarek et al. (15) as improving student engagement and understanding:

> *"so that's been really useful, especially when you have tutors which are like engaging and getting you a bit more involved as well." (Student Participant 1)*

- Ability to ask a question in the chat function on Teams, however, rather than verbally asking:

> *"If I have a question though I do always just ask it and that's no different to being face-to-face, but I think that's just me." (Student Participant 2)*

- Anonymised chat function may help overcome reluctance to speak in the online sessions:

> *"sometimes these are people that would be asking questions in class, UM, but for some reason they wouldn't online… don't know what changes?" (Student Participant 2)*

> *"We need to, we need to anonymize the chat line basically so that they can ask questions most of them are so scared." (Teacher Participant 2)*

> *"it doesn't help that sessions are recorded because they know that people are gonna hear them later." (Student Participant 2)*

- Being alone at home rather than with colleagues created a barrier regarding group or collaborative work:

> *"there have been other classes where somebody is asked a question and then you've bounced ideas off each other, but it's only really two people. They're speaking like two students and a teacher, and so I don't think the group discussion happened so much." (Student Participant 2)*

The difficulty for staff was finding the right approach to online teaching, as their point of reference was in-person teaching. For some, it was related to their speaking, teaching style, and ability to use body language and read body language:

> *" face to face, then you, It's more a personable experience because you can see the entire person" (Teacher Participant 5)*

> *"I use my hands and my body, my body movement and be like the conductor in an orchestra. You can't do that online. Yeah. So you know, So you know, teaching is often putting on a performance, isn't it?" (Teacher Participant 4)*

Nonetheless, adjustments were made and staff found ways to make the online environment work for them using synchronous and asynchronous formats to support student learning:

> *"you can share PowerPoint presentations quite easily. You can share articles; you could show them pictures. There's even a blackboard thing." (Teacher Participant 5)*

> *"… it would be difficult to make notes. Whereas with pre-recorded lectures you can go to the point that you wanted like a like." (Student Participant 2)*

> *"Play back basically." (Student Participant 2)*

4.4 Literacy

Concerns regarding literacy, including digital literacy and pedagogical literacy, are essential to address as the narrative seemingly shows that even with a return to on-campus activities, there are benefits to keeping the mix of synchronous, asynchronous, online, and on-campus modes. The affordance offered by the technology and ability of a teacher to share their screen enabled resources such as photographs to be viewed more clearly by students; however, conversely, teachers were unable to pass around physical objects such as models in the online environment. However, with this technological advancement, similarly to Kumar and Vigil (16), students highlighted that staff had developmental needs that would require support, such as how to fully use the technology—such as sharing documents online. Indeed, the online teaching process requires support in technological and pedagogical aspects, including tools, resources, and training courses, as echoed by others (17). This convenience and comfort of learning from anywhere at any time is similarly reported by others (18). There were narratives that also highlighted the ability to have an individualised pace of learning, which was found by others (19). There was also evidence that the lack of good internet access, adequate place for online teaching, difficulties in producing teaching materials, and home/personal life commitments had a significant impact on the quality of life and anxiety scores for teachers (20):

> *"people have a lot of Wi-Fi problems. So if they can't access a tutorial because of their Wi-Fi problems." (Student Participant 2)*

> *"technical problems. It's not always that easy to get, good Internet." (Teacher Participant 3)*

> *"So if they can't access a tutorial because of their Wi-Fi problems" one student points out. (Student Participant 2)*

> *"they found it quite hard to adapt at the beginning they wouldn't know how to share their screen either." (Student Participant 2)*

> *"they didn't know how to share screen. And so I think. I think they are trying their best, but maybe like training on technology might be useful." (Student Participant 2)*

> *"it was so fairly daunting to start off with because you're unfamiliar with the technology." (Teacher Participant 1)*

> *"haven't totally embraced all the features of teams about sort of using breakout groups." (Teacher Participant 1)*

> *"If we had adequate sort of office space, from which to work, then we could deliver online teaching to students who aren't in the building, whilst being physically in the building ourselves to go on and do clinical teaching later on." (Teacher Participant 3)*

> *"They felt frustrated and had to use any available means for example when on campus when I did the online teaching and I was using my phone because the facilities are not there." (Teacher Participant 2)*

Both students and staff highlighted concerns and anxiety around connectivity issues, as they proved to be a barrier for some in accessing the sessions. Students also could see the staff struggling with the technology and reported highlighting developmental needs in technology usage in teaching. Interestingly, staff also highlighted technical issues, lack of access to adequate resources, and the need for more support and training.

The accounts also made apparent suggestions to provide appropriate resources on campus to enable the delivery of online tutorials—such as quiet office space with computer access. It was also noted that some students were accessing sessions using mobile phones and tablets rather than computers, which potentially impacted their experience. However, this issue is related to on-campus challenges. The availability of recordings, which are a technology affordance, was deemed much more useful in case students encounter issues attending in person at the time of the tutorial.

4.5 Learning outcomes

The accounts represented a mix of views about how learning outcomes are met and how these are met in different delivery modalities. The results confirm unfavourable views around the acquisition of clinical skills in an online teaching environment, which was similar to previous empirical research presented by others (21, 22). There were concerns about the mix of delivery methods and the disruption, leading inevitably to skill deficits within the cohort of students' experiences during the pandemic (23). Previous research suggests concerns about online learning not being the best way of communication, especially in medical and dental programmes. The narrative accounts presented comments:

> *"It might sometimes occur bit off topic, and then you still discussing dentistry and stuff, but just a bit not what was on the kind of written for that tutorial. So yeah, but we do cover most of the outcomes and stuff." (Student Participant 1)*

> *"We are actually generating a lot more material now, resources and updating the resource is because we're moving it online" (Teacher Participant 1) and "We've made sure that those tutorial sessions are delivering certainly what we intended before and probably more so because of where we are." (Teacher Participant 1)*

> *"Without the Face-to-face clinical teaching, inevitably, they haven't gained as much of a grasp of the clinical things." (Teacher Participant 3)*

> *"the practical bits are less, less easy to grasp virtually or online." (Teacher Participant 3)*

> *"don't understand about independent self-regulated learning" (Teacher Participant 5) and "I think it's about them not taking accountability for their learning." (Teacher Participant 5)*

In terms of learning outcomes, students felt that some were readily met in the online environment, such as specific tutorial topics. Their confidence in approaching specific clinical situations was increased. As echoed in Jabbour and Tran (24), students mentioned that the sessions were useful, however, the students highlighted that these sessions do not substitute clinical experience. On the other hand, staff felt that delivering academic content and associated learning outcomes was achieved satisfactorily, with a great volume of online resources generated for student use. Interestingly, more care seems to be put into online teaching because it must also cover more than the clinical experience. However, there was a concern about the inability to teach the hands-on clinical material or see whether the online teaching impacted the students' clinical activity. Among clinical aspects, the staff highlighted communication skills and the need to observe interactions with patients to give feedback to students regarding their communication skills. There were accounts that seemingly suggest that the students lacked maturity and the ability to manage their own learning, which is fundamental to any online delivery of the programme.

4.6 Scenario-based and psychological

With regard to the period following an online teaching session, although the main concern was the potential impact on future clinical activity due to the lack of hands-on experience, as detailed above, there were also questions about the impact on student and staff wellbeing, mentioning the following:

- Some sessions were very long, where 3-h clinic sessions turned into 3-h online equivalent sessions with case studies.
- Tutorials had to be all placed into an online day.

This meant that students would have back-to-back online seminars in different disciplines and teachers would have back-to-back seminars for different year groups. A novel issue raised by students was what we have categorised as "online fatigue". Difficulties arising from sitting in front of a screen for long periods of time also lead to a loss of concentration:

> *"sometimes those classes would overrun so you would just be sitting down for three hours and it would be really hard to concentrate. So, you just started to get a bit fatigued and lose your concentration faster." (Student Participant 2)*

> *"quite, quite tiring, online teaching all day, I mean, I think it must be quite tiring online learning." (Teacher Participant 3)*

> *"to be timetabled some downtime or in-between those sessions" and "for them to just reflect or just to get a cup of tea and stretch their legs." (Teacher Participant 3)*

> *"cameras off and the teacher can't see us, so we're kind of fidgety. And we're not paying attention." (Student Participant 2)*

Some staff also pointed out the inability to interact on a more social level with students in the online environment. They would not have "*the social interaction and downtime between lessons*" *(Teacher Participant J3)*.

The study has limitations. It presents narrative accounts from a small number of participants. However, the recurring themes represent saturation within the presented narratives. It is also important to consider and account for the specific needs of different year groups. The time commitment presented a challenge for many who expressed interest in participating in the study.

5 Conclusion

The approach we adopted in this study provided researchers with the opportunity to explore participants' perspectives and experiences and identify potential areas for further research. In addition, it allowed researchers to gain insight into the challenges and opportunities that teachers encounter in their classrooms.

In both teacher and learner populations, we observed significant concerns regarding engagement, not limited to attendance, connection, and interaction, and we noted an emerging concept of online fatigue. Concerns like these can undermine the teaching and learning process.

To help learners and teachers focus on the educational intent and content, clinical learning should be separated from clinical sessions. Simulations and virtual patients can be used to establish clinical learning outcomes prior to the expected application chairside. By the time students arrive at clinics, they should be supported, prepared, and scaffolded, regardless of their learning style.

It is important to note that both teaching and learning communities now have alternatives to conventional methods and modalities. Thus, returning to a full-time campus presence would not be feasible. However, to ensure a more conducive learning environment, it is crucial to take stock of online fatigue highlighted by both students and teachers when online sessions were introduced. Further research is recommended to provide evidence-based support for this approach as "improvement."

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors without undue reservation.

Ethics statement

The study has been approved by the KCL Research Ethics Committee (LRS-20/21-20813, PNM Research Ethics Panel). The participants provided their written informed consent to participate in this study.

Author contributions

MN: Conceptualization, Formal Analysis, Methodology, Project administration, Supervision, Visualization, Writing – original draft, Writing – review & editing. AA: Conceptualization, Formal Analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. SR: Conceptualization, Formal Analysis, Methodology, Writing – original draft, Writing – review & editing. JT: Conceptualization, Methodology, Writing – original draft, Writing – review & editing. MD: Investigation, Writing – original draft. AB: Conceptualization, Methodology, Writing – original draft. JS: Conceptualization, Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing.

Funding

The authors declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

1. Kintu MJ, Zhu C, Kagambe E. Blended learning effectiveness: the relationship between student characteristics, design features and outcomes. *Int J Educ Technol Higher Educ*. (2017) 14(1):7. doi: 10.1186/s41239-017-0043-4

2. Alammary A. Blended learning models for introductory programming courses: a systematic review. *PLoS One*. (2019) 14(9):e0221765. doi: 10.1371/journal.pone.0221765

3. Tong DH, Uyen BP, Ngan LK. The effectiveness of blended learning on students' academic achievement, self-study skills and learning attitudes: a quasi-experiment study in teaching the conventions for coordinates in the plane. *Heliyon*. (2022) 8 (12):e12657. doi: 10.1016/j.heliyon.2022.e12657

4. Nasseripour M, Turner J, Rajadurai S, San Diego J, Quinn B, Bartlett A, et al. COVID 19 and dental education: transitioning from a well-established synchronous format and face to face teaching to an asynchronous format of dental clinical teaching and learning. *J Med Educ Curric Dev*. (2021) 8:238212052199966. doi: 10.1177/2382120521999667

5. Almpanis T, Joseph-Richard P. Lecturing from home: exploring academics' experiences of remote teaching during a pandemic. *Int J Educ Res Open*. (2022) 3:100133. doi: 10.1016/j.ijedro.2022.100133

6. Littlejohn A, Gourlay L, Kennedy E, Logan K, Neumann T, Oliver M, et al. Moving teaching online: cultural barriers experienced by university teachers during COVID-19. *J Interact Media Educ*. (2021) 2021(1):1–15. doi: 10.5334/jime.631

7. Overcash JA. Narrative research: a review of methodology and relevance to clinical practice. *Crit Rev Oncol Hematol*. (2003) 48(2):179–84. doi: 10.1016/j.critrevonc.2003.04.006

8. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol*. (2006) 3(2):77–101. doi: 10.1191/1478088706qp063oa

9. Sarfraz F, Daka H, Zubair A, Sarfraz F. The viability of blended model in undergraduate medical education in COVID-19 pandemic. *Pak J Med Health Sci*. (2022) 16(1):561–5. doi: 10.53350/pjmhs22161561

10. Goetz K, Wenz H-J, Hertrampf K. Certainty in uncertain times: dental education during the COVID-19 pandemic—a qualitative study. *Int J Environ Res Public Health*. (2023) 20(4):3090. doi: 10.3390/ijerph20043090

11. Wang C, Tee M, Roy AE, Fardin MA, Srichokchatchawan W, Habib HA, et al. The impact of COVID-19 pandemic on physical and mental health of Asians: a study of seven middle-income countries in Asia. *PLoS One*. (2021) 16(2):e0246824. doi: 10.1371/journal.pone.0246824

12. Aivaz KA, Teodorescu D. College students' distractions from learning caused by multitasking in online vs. face-to-face classes: a case study at a public university in Romania. *Int J Environ Res Public Health*. (2022) 19(18):11188. doi: 10.3390/ijerph191811188

13. Kerkstra RL, Rustagi KA, Grimshaw AA, Minges KE. Dental education practices during COVID-19: a scoping review. *J Dent Educ*. (2022) 86(5):546–73. doi: 10.1002/jdd.12849

14. Iqbal FM, Lam K, Sounderajah V, Clarke JM, Ashrafian H, Darzi A. Characteristics and predictors of acute and chronic post-COVID syndrome: a systematic review and meta-analysis. *EClinicalMedicine*. (2021) 24(36):100899. doi: 10.1016/j.eclinm.2021.100899

15. Kaczmarek K, Chen E, Ohyama H. Distance learning in the COVID-19 era: comparison of student and faculty perceptions. *J Dent Educ*. (2021) 85(Suppl. 1):1197–9. doi: 10.1002/jdd.12469

16. Kumar S, Vigil K. The net generation as preservice teachers. *J Digit Learn Teacher Educ*. (2011) 27(4):144–53. doi: 10.1080/21532974.2011.10784671

17. do Amaral JHL, Palmier AC, Werneck MAF, Lucas SD, Senna MIB. Challenges and dilemmas for dental undergraduate teaching with the advent of COVID-19. *Pesquisa Brasileira Em Odontopediatria E Clínica Integrada*. (2021) 21:e0147. doi: 10.1590/pboci.2021.067

18. Hertrampf K, Wenz HJ, Kaduszkiewicz H. Suspension of face-to-face teaching and ad hoc transition to digital learning under COVID-19 conditions—a qualitative study among dental students and lecturers. *BMC Med Educ*. (2022) 22:257. doi: 10.1186/s12909-022-03335-5

19. Nijakowski K, Cieślik K, Łaganowski K, Gruszczyński D, Surdacka A. The impact of the COVID-19 pandemic on the spectrum of performed dental procedures. *Int J Environ Res Public Health*. (2021) 18(7):3421. doi: 10.3390/ijerph18073421

20. Puccinelli PJ, da Costa TS, Seffrin A. Reduced level of physical activity during COVID-19 pandemic is associated with depression and anxiety levels: an internet-based survey. *BMC Public Health*. (2021) 21:425. doi: 10.1186/s12889-021-10470-z

21. Hassan R, Khalifa AR, Elsewify T, Hassan MG. Perceptions of clinical dental students toward online education during the COVID-19 crisis: an Egyptian multicenter cross-sectional survey. *Front Psychol*. (2022) 12:704179. doi: 10.3389/fpsyg.2021.704179

22. Jum'ah AA, Elsalem L, Loch C, Schwass D, Brunton PA. Perception of health and educational risks amongst dental students and educators in the era of COVID-19. *Eur J Dent Educ*. (2021) 25(3):506–15. doi: 10.1111/eje.12626

23. Nazir MA, Khan MR. Exploring the barriers to online learning during the COVID-19 pandemic. A case of Pakistani students from HEIs [higher education institutions]. *GIST Educ Learn Res J*. (2021) 23:81–106. doi: 10.26817/16925777.1195

24. Jabbour Z, Tran M. Can students develop clinical competency in treatment planning remotely through flipped collaborative case discussion? *Eur J Dent Educ*. (2023) 27(1):69–77. doi: 10.1111/eje.12778

frontiers | Frontiers in Oral Health

TYPE Original Research
PUBLISHED 19 April 2024
DOI 10.3389/froh.2024.1272692

OPEN ACCESS

EDITED BY
Khalid Almas,
Imam Abdulrahman Bin Faisal University, Saudi Arabia

REVIEWED BY
Adriana Zilly,
Western Parana State University, Brazil
Bhojraj Nandlal,
JSS Dental College and Hospital, India
Muhammad Nazir,
Imam Abdulrahman Bin Faisal University, Saudi Arabia

*CORRESPONDENCE
Adam Hasan
✉ adam.hasan@kcl.ac.uk

RECEIVED 04 August 2023
ACCEPTED 12 March 2024
PUBLISHED 19 April 2024

CITATION
Hasan A and Jones B (2024) Assessing the assessors: investigating the process of marking essays.
Front. Oral. Health 5:1272692.
doi: 10.3389/froh.2024.1272692

Assessing the assessors: investigating the process of marking essays

Adam Hasan[1]* and Bret Jones[2]

[1]Centre for Dental Education, Faculty of Dentistry, Oral and Craniofacial Sciences, King's College London, London, United Kingdom, [2]College of Engineering, Computer Science and Construction Management, California State University, Chico, CA, United States

Pressure for accountability, transparency, and consistency of the assessment process is increasing. For assessing complex cognitive achievements, essays are probably the most familiar method, but essay scoring is notoriously unreliable. To address issues of assessment process, accountability, and consistency, this study explores essay marking practice amongst examiners in a UK dental school using a qualitative approach. Think aloud interviews were used to gain insight into how examiners make judgements whilst engaged in marking essays. The issues were multifactorial. These interviews revealed differing interpretations of assessment and corresponding individualised practices which contributed to skewing the outcome when essays were marked. Common to all examiners was the tendency to rank essays rather than adhere to criterion-referencing. Whether examiners mark holistically or analytically, essay marking guides presented a problem to inexperienced examiners, who needed more guidance and seemed reluctant to make definitive judgements. The marking and re-marking of scripts revealed that only 1 of the 9 examiners achieved the same grade category. All examiners awarded different scores corresponding to at least one grade difference; the magnitude of the difference was unrelated to experience examining. This study concludes that in order to improve assessment, there needs to be a shared understanding of standards and of how criteria are to be used for the benefit of staff and students.

KEYWORDS

assessment, marking practice, criteria, grading, holistic marking

1 Introduction

Growing pressures for accountability, transparency, and consistency from universities, government and from potentially litigious students are driving the need to account for validity and reliability in assessment (1). The increase in undergraduate fees further heightens the need for a robust assessment process (2). The quest for reliability can, however, skew assessment away from judgements of complex learning towards the assessment of simple and unambiguous achievements (3). Considerations of cost add to the skew towards assessment of what is easily measured and reliable, for example, the multiple-choice-question (MCQ) format, but which is a poor indicator of the candidate's higher order skills, professional-level judgement, and cognitive achievement (4).

Assessment has an effect on curriculum coverage. There is also a relationship between assessment and the way in which the subject is presented in teaching (3, 5). This in turn affects, through the tasks in which the students engage, what and how the students learn (5). In dental surgery, we would wish candidates to develop higher order skills,

analytical skills, application of knowledge, investigation, reasoning and interpretation. Assessment should reflect this expectation. Essays require students to select and synthesise information, and to demonstrate their practice knowledge and understanding (4). In order to improve reliability in essay marking it is important to know how examiners deal with exam manuscripts. Whilst there may be an argument for removing essays because of the inter-examiner variation in grade awards, this would remove a valuable part of the assessment, as the ability to synthesise information, construct arguments and apply knowledge in depth cannot easily be achieved in other assessment formats (6).

In order to improve the assessment process, it is important to understand the problems with essay marking from the perspective of the examiners' process and experience, so that appropriate strategies can be employed to enhance assessment quality and reliability. Ecclestone (7) reminds us that few in higher education are well-informed about the literature on assessment, and whilst assessors may be experts in their own subject, they are not experts in assessment. This lack of expertise in assessment results in underlying skewing dynamics in marking practice being unrecognised and uncorrected (8, 9). In fact, how assessors mark student work is not well known. Recent qualitative and quantitative research to explore marking practice continues to reveal the complexity of these little understood assessment practices (10–12).

Essays are usually assessed in one of two ways, either by mark-remark procedures with different markers scoring the same piece of work (inter-rater reliability) or by the same marker marking the same pieces of work on different occasions (intra-rater reliability). Markers are affected by characteristics of the students: presentation, clear handwriting, gender of candidate and marker (13). Clearly there are inter-rater differences in marking and in assessor understanding of the (and of their own) marking process, all of which can impact on assessment. Marker training and the provision of scoring rubrics can enhance reliability (14, 15). Inter-examiner moderation is also crucial when multiple examiners are involved, but that topic lies outside the scope of this study.

This paper argues that attention needs to be focused on inter-examiner agreement. Performance assessment is highly subjective, as it relies on professional judgement. However, if the assessors are trained, provided with scoring rubrics, and given exemplars of performance for each grade, then inter-examiner agreement can be high (16, 17). Increasing the number of tasks can increase score reliability and enhance generalisability; the underlying assumption is that these traits are stable over time. It is known that when examiners mark essays, scores can vary widely, however it is not known how examiners score essay papers in dentistry.

This study posits the following research questions:

How do examiners assign scores to candidate's essays?

1. How do examiners make judgements whilst marking essays?
2. How do examiners interpret the marking rubrics in assigning candidate scripts to particular grade categories when marking essays?

Issues impacting on assessment outcomes are considered in this section.

1.1 Context

The research setting is a dental school in the UK, with a clear emphasis on maintaining a cutting-edge research profile. The principal function is the provision of teaching and learning support for dental students, although the emphasis is clearly on research to maintain a cutting edge and thus an attractive image to prospective students. This has influenced staff to engage in research more readily and, unfortunately, to withdraw from teaching including the assessment process. The poor rating in assessment and feedback given by students in national surveys (18) supports the researcher's impression that assessment is not given the importance it deserves particularly in this era of accountability. The management structure is hierarchical with all staff taking part in formative and summative assessments. The staff involved in the examination process include both junior and senior members of staff from all subject disciplines.

There are over 80 students in Bachelor of Dental Surgery (BDS) year 4, and an examining team of 9. The examination process involves junior and senior members of staff from relevant subject disciplines. This study focused on assessors marking a task on the role of medical histories and radiological assessment in periodontal management. This assessment research is valuable to the dental school because it will (1) help to ensure candidate performance is appropriately rewarded (2) fill a void in the literature on essay marking in higher education in dentistry (3) enable summative assessment to be improved. As the final exams enable registration with the General Dental Council (GDC), the implications of this research could have a positive impact on the public.

2 Methodology

This study employs a mixed-methods approach: a quantitative approach for numerical data and score analysis and a qualitative approach to analyse the textual data and examiner process. This article concentrates on the qualitative aspects, using an interpretivist paradigm for analysis (19). An interpretivist paradigm assumes social reality is embedded in context thus enabling the exploration of how all nine examiners in this team use essay plans (rubrics) to assign scores to scripts (19).

For both research questions "think aloud interviews" (in which a participant verbalises his/her thought processes while working on a task) are used to investigate how examiners make judgements whilst marking essays (20). This technique helped to recruit all examiners in this team, and allowed them not to disrupt their routines or create additional burdens. This abrogates the need to engage in a post-marking, retrospective reflection/interpretation or to schedule more time-consuming semi-structured interviews in which the interviewees try to recall their experiences of marking in some detail. The assessment question and examiner marking guide is provided in Figure 1. The consistency in marking was also explored by asking examiners to re-mark anonymised essays they have previously marked. An interval of 9 weeks was selected so as not to interfere with academic duties and to maximise the period between the first marking and remarking before staff took leave. In order to compare how

Question: What are the commonest medical conditions and treatment which may affect periodontal management? How do they affect periodontal treatment?

Examiner Marking Guide:

Smoking: increases tissue loss in periodontitis. Reduces BOP, and response to treatment. Cessation or reduction will help improve treatment results.

Diabetes: increases periodontal disease and inflammation. If well-controlled, does not affect treatment response. Complications and their medical treatment may affect management, eg Ca channel-blockers for hypertension, ciclosporin with renal transplants, cardiovascular disease.

Drugs: gingival overgrowth with phenytoin, ciclosporin and Ca channel blockers. Responds to good plaque control, but may sometimes need surgery.

Less common but worthy of mention in best answers:

Down syndrome: effects on host response and collagen metabolism contribute to increased disease. Most Down patients are able to perform good OH, but some who are severely learning-disabled may not.

Recreational drugs: psychological abnormalities may disrupt OH and affect patient's attitude and behaviour, eg alcoholic depression, cannabis psychosis. Methamphetamines (Speed, Ecstasy) create xerostomia with a significant thirst which some quench with excessive carbonated drinks leading to erosion and caries, including root caries. Ecstasy also causes bruxism, which can affect mobility and tooth loss.

FIGURE 1
Assessment question and examiner marking guide.

consistent the scores and grades were at the time of marking and again after an interval of 9 weeks, a paired t test was used. The answers will help to develop an assessment process that is more reliable and a closer reflection of candidate performance.

2.1 Recruitment

The researcher approached examiners individually and invited them to take part; in this way only the researcher knew who the participants were. In order to encourage participation of the entire team of 9 examiners who are academics with heavy teaching and clinical loads, it was crucial to employ methods that are time-efficient and easy to undertake; participants are therefore asked to record either in a written or oral form how they go about marking essays. This interview is conducted in the most convenient location for the participant, his/her office. The researcher does not use group interviews as group interview or focus groups are not designed to yield individual deep reflective data (21).

2.2 Ethical approval and issues in conducting this research

Informed consent was obtained from all participants. Participant identity is protected by anonymising the audio-tapes and coding any names in transcripts. The identity of students and staff is protected by using codes in the exam results. No year is indicated in the tabulated results, so that neither staff nor candidates from the cohort can be identified from tables of results. Ethical approval was obtained to carry out this study from King's College London (BDM/09/10-83) and from the Director of Education.

2.3 Analysis

The audiotapes were transcribed by a trained transcriber and verified by the researchers (Adam Hasan, Bret Jones) using an interpretativist approach (19). The researchers examined the transcripts and mapped understandings shared and not shared by respondent. The researchers coded the interview data, creating open codes as the transcripts are read (22). As codes were accumulated, the researchers re-coded to ensure there is consistency in coding transcripts, and then began to sort coding into themes (22, 23). Examiners reviewed their own transcribed comments and agreed their validity. No amendments were needed to the text. Nine Examiners were asked to re-mark essay scripts, so that we could compare consistency in assigning scores to previously marked scripts. These findings helped triangulate data, thereby gaining confidence in the interpretation of the responses.

3 Data presentation and discussion

The examining team consisted of 9 staff and all 9 members (E1–9) of the examining team consented to participate in this study.

3.1 Skewing of essay scores is multifactorial

Human resources, timing and use of the generic marking scheme (MS) all impact on assessment (24). Whilst most examiners use the essay marking guides when deciding scores, not all are using the generic MS which provides descriptors for each percentage band (Table 1). The descriptors are framed in comparative terms, and this may partly explain the tendency to mark within the range 30%–70% where the examiners can more readily interpret and apply better defined criteria (Table 1). However, as Price and Rust (26) have already found, having explicit criteria and grade descriptors does not improve the understanding of standards. This finding is also suggested by inconsistent essay marking in this study. The re-marking of scripts revealed that only 1 of the 9 examiners achieved the same grade category. All examiners awarded different scores, corresponding to at least one grade difference (6 of the 9 assessors), but sometimes revealing differences corresponding to 2 grade categories in 3 assessors (paired t-test, df = 8, $t = 2.62$, $p < 0.05$). The magnitude of the difference in scores was unrelated to experience examining (Table 2).

In terms of human resources, increasing numbers of examiners are needed to cope with larger cohorts of candidates, which deepens concerns for validity and reliability as examiners may inadvertently employ multiple sets of criteria (26). It is now acknowledged that local communities are less able to establish standards unless both explicit as well as tacit knowledge about the standards are transferred (8). Despite this, the Quality Assurance Agency, is the independent expert quality body for higher education across the UK (27), has attempted to set explicit standards, failing to recognise the importance of tacit knowledge in assessment. Without assessment standards and a shared understanding of criteria, consistency is less likely. This is magnified when there are multiple markers (8, 28).

TABLE 1 Marking scheme grade descriptors (25).

Distinction 70+	*Thoughtful answer informed by wider reading showing clarity of thought and personal insight*	
	Understanding	thorough understanding demonstrated with an insightful and creative analysis
	Selection & coverage	comprehensive range of relevant evidence used, demonstrating independent study and extensive reading
	Structure	clear, fluent, integrated and focused
	Knowledge	Excellent level of knowledge, no inaccuracies
	General	90 + creative and sophisticated
		80 + striking insight demonstrated
		70 + excellent in all areas, displaying originality
Merit 60–69	*Good understanding of basic principles & relevant evidence, with a coherent & logical argument showing analytical ability*	
	Understanding	good understanding of all key issues and wider implications with a convincing analysis
	Selection & coverage	breadth in examples and evidence used without any major omissions, evidence of extended reading
	Structure	coherent and logical
	Knowledge	Good, above average level of knowledge, minor inaccuracies only
	General	excellent in some areas or of high quality in all
Pass 50–59	*Sound understanding demonstrated*	
	Understanding	sound understanding of basic principles and main issues with some evidence of analysis or synthesis
	Selection & coverage	appropriate material but little evidence of extended reading, possibly some minor omissions
	Structure	clearly presented but little development of answer
	Knowledge	Average, acceptable level of knowledge, minor inaccuracies, no serious errors of fact
	General	lower quality answer in at least one area
Borderline Fail 46–49	*Basic understanding of the main issues demonstrated, too little information (NB. Could be compensated by other questions)*	
	Understanding	general knowledge demonstrated but analysis limited in depth and breadth. Safe but lacks some demonstrated knowledge.
	Selection & coverage	skeletal coverage of basic material, some omissions but not to detriment of a patient
	Structure	inadequately presented
	Knowledge	Inadequate level of knowledge shown. Significant inaccuracies, but none to detriment of patient care
	General	superficial and a low quality answer
Fail 0–45	*Unsystematic, incomplete and/or inaccurate*	
	Understanding	key issues not identified, poor analysis or none. Not safe to proceed with this level of understanding
	Selection & coverage	some inaccuracies or omissions, excessive inappropriate material
	Structure	argument sketchy, loose ends, disorganised
	Knowledge	Inadequate level of knowledge, inaccuracies shown that may be to detriment of patient care. Not safe to proceed.
	General	36–45 some knowledge but poorly presented. Not shown to be safe.
		26–35 answered only in part and flawed. Not shown to be safe.
		16–25 deeply flawed or unacceptably brief. Unsafe.
		1–15 irrelevant or unintelligible. Grossly unsafe. 0—totally inadequate or no attempt to answer question

TABLE 2 Summary of examiners and length of commentary (25).

EXAMINER	E1	E2	E3	E4	E5	E6	E7	E8	E9
Training in examining	No	No	No	No	No	No	No	Yes	No
Post-graduate Qualification in Education	Yes	Yes	Yes	No	No	No	No	No	No
Experience in examining (years)	10	3	5	1	9	30	1	1	34
Length of commentary	715	3,486	954	739	1,517	757	1,334	1,099	511

Timing is linked to both MS and human resources issues, in that the skewing problem is not solved simply by minimising the number of examiner pairs in an attempt to avoid the problem of multiple sets of criteria. The potential for skewing still exists as a result of examiner exhaustion in large-scale marking, as does the potential for examiners simply to mark essays within the limited time available with little regard for the quality of assessment (8, 24). The researchers agree with Knight (21) who finds when there are increased pressures due to increased workloads and reducing resources; the impact can only be negative on assessment. One examiner voiced this pressure.

> E3 There's no time to reread all, just do the first lot and then when I'm in the zone as it were, I crack on using then time I have, since we have such a tight turnaround time for these, I'd be thinking of how much time I have, then make it fit the number of essays I have to mark. It's not ideal but that's all I can do.

3.2 Positivist background and discomfort with subjectivity in marking

In most of the commentaries there is evidence, either explicit or implicit, of differing philosophical perspectives, with different examiners seeking different levels of "truth" and "correctness". For some, the text can only have one meaning. E6, for example, was very clear about what was right and wrong within the script s/he marked.

> E6 Some important points, DPT, not differentiating, important points. That's wrong-2 views at right angles….change the views for furcations.

E6 is a well-established researcher and clinician, and clearly has a positivist epistemological viewpoint where s/he judges candidate responses dichotomously as right or wrong, with no degrees of correctness. Other examiners also reveal positivistic perspectives, mentioning "bias" and the importance of avoiding bias. The strong clinical and scientific background of the examiners may contribute to a feeling of discomfort in the perceived subjectivity of some aspects of marking. However, for those with post-graduate qualifications in education, the distinction between correct and incorrect is less rigidly defined. This more nuanced marker perspective is reflected in the relatively vague judgement language they employ, as if they are trying to determine the candidate perspective. They are, in a way, engaging in a dialogue with the author, a dynamic also found in Crisp (29). This suggests that those examiners with post-graduate educational training may be able to mitigate the inappropriate application of positivist perspectives to complex and nuanced assessment tasks, such as essays. What is clear is that these differing philosophical perspectives lead to different assessment outcomes. The implication is that examiners need to be aware of and clear about their own implicit philosophical perspectives, conditioned by their background and training, as they approach their understanding of shared criteria.

3.3 Marking criteria are used to rank candidates thwarting criterion-referencing

Common to all examiners in this study, irrespective of the marking strategy used, is the comparison and ranking of one candidate's script in relation to another.

> E6 This does not have the structure of the first one. It's a pass, 1–2 marks below the first one, 56–57.

Norm-referencing is grading in relation to other candidates and is perhaps inadvertently promoted by the generic criteria in the MS which are couched in relative rather than absolute terms. Norm-referencing occurs because in practice it is easier to rank than to measure against criteria or an absolute standard (8). However, it is inappropriate, as there will always be some candidates who lie within the top 4% but none may have reached the level of performance/achievement that is compatible with safe clinical practice, consequently standards may vary widely over time. Criterion-referencing is preferred because grading using criteria reflects individual achievement rather than the achievement in relation to other students in the cohort. This is particularly important when the safety of the public has to be protected.

All examiners are clearly ranking the scripts through comparison rather than criteria. This further supports the notion that the 0–100 scale does not work well with these examiners. E1 believes that marking cannot be accomplished with the precision implied by the 0–100 scale, citing the difficulty in distinguishing a score of 51% from 52%.

> E1 I aim to give a range representing where I think the paper sits in the marking range and a specific mark, the range indicates how far I am prepared to move if the co-examiner has a different mark. I don't really believe I can give a

> specific mark, and be able to distinguish between 51% and 52%, this seems quite ridiculous to me.

It seems that ranking the scripts is easier to do than applying criteria (8, 29). According to Lumley (30), if essay marking guides do not answer the examiner's queries about script marking, the markers then attempt to reconcile their impression of the script with the rating guidance. It is a finding that matches this study. Examiners resort to using the generic MS as well as essay marking guides or model answers, but do not always find the answers they seek. The essay marking guide differs from a comprehensive "model answer", presenting a problem to the inexperienced examiners who are in need of more guidance in how to use criteria and make judgements.

> E7 Looking at the model answer it doesn't really give a lot of flexibility in delineating between the passes, goods and excellent. You've got extra additional marks for the cone beam CT and that's as much that would take somebody into a better category, but there isn't a lot of guidance on there on what a pass would be, or what a good pass would be or…

There appears to be different conceptions of what criteria-based marking/grading means; all examiners in this study are applying their own individualised interpretations of assessment when marking. Agreeing with Price (8) and Sadler (31), we found examiners within the same team had different theoretical interpretations translating to related but different practices (8, 31). Unless the assessment values and local practice are shared amongst staff, there is little chance of understanding what is meant by criteria and how these are to be applied (8).

The use of criteria in essay marking enables assessment of an absolute, rather than a relative, standard to be determined; this helps improve reliability and helps to reassure the public that candidates have reached the required standard (32). Criterion-referenced assessment is supposed to be a low-inference procedure (13) because of the careful specification of the domain or construct and thorough sampling of it. The specification is necessarily detailed; however, if too narrowly defined the assessment criteria lead to fragmentation of the task and a proliferation of discrete assessment tasks (3).

It would seem that knowing more about assessment and holding post-graduate qualifications in education, as do E1–E3, is not enough to ensure consistency in marking practice. Only two, E1 and E2, explicitly refer to criteria in their interviews. E2 highlights the importance of clarity of marking criteria and how lack of it impacts on consistency.

> criteria for marking because it should be criterion referenced when different markers… you don't have clear cut criteria it's difficult to get consistency between markers. What I find important with essays is that you should have clear cut with essays as in they are extremely time-consuming and if you're marking essay papers. I do find that there are some problems.

Designing criterion-referenced assessment is difficult, particularly in advanced levels, involving complex subject areas, because "as the requirements become more abstract and demanding so the task of defining the performance becomes more complex and unreliable" (3). Problems can arise if question items do not reflect the intended constructs (under-represented constructs). It will then tend to unidimensionality and measurement of a single underlying attribute. In-so-doing, the test measures part of the construct, rather than its multi-dimensionality. The resulting scores cannot then be broadly interpreted (13, 33). In other words, incomplete assessment of the construct compromises validity and risks failing candidates unnecessarily. The tacit knowledge characterising "expert" performance complicates determination of valid constructs.

It is interesting to note that none of examiners refers to assessment objectives at all. There is no shared understanding amongst this team of examiners, but discernible confusion about how criteria should be used to determine standards. For many of the examiners in this study, there is implicit assessment of criteria, in order to determine the standard; however there is a lack of clarity between what is meant by criteria and standards, a finding that echoes Sadler (31). For some inexperienced examiners, determination of the higher passing levels is achieved by rigidly adhering to the essay marking guide; however, their consistency in determining this standard seems compromised by not knowing how to assess the additional contextualisation and quality of responses provided by better candidates. The net effect is reliance on other criteria which are not in the essay marking guide or marking scheme:

> E7 It's still ok but still they haven't brought a lot in CBCT aspect, but it's a fairly ok answer. It's got most of the information. Doesn't really have a beginning and an end it's just somebody who has thrown all the information on the paper which is easy to pick up but it's very different from that first one. And it's got the same, less than the last one. I'd say it's a very safe pass, 58–59.

The only criterion directly relevant to the notion of standards in clinical practice is safety, as mentioned by all examiners, and is used to distinguish pass/fail. However, this criterion alone is unlikely to be sufficient to compensate for the diverse range of examiner marking practices but rather adds to the numerical skewing described earlier.

3.4 Holistic or analytic approach to essay marking?

The holistic scoring method is based on the theory that a whole piece of writing is greater than the sum of its parts (6). In this practice, essays are read for the total impression they create, rather than for individual aspects. The assessor is not overly concerned with any one aspect of writing, but looks at the response as a whole. The markers in this study could be categorised crudely as one of two types:

> Analytic-like; or

> Holistic-like

There are 3 examiners, E2, E3 and E8, who appear to be marking using an analytic framework, whereas the others are marking using a general impression system or holistic scoring system. E2's analytic approach to marking is captured in this excerpt:

> E2 "…so that I could have a checklist to see how many they had covered, and if they had were giving me accurate responses and they were current and up-to-date."

E2 and E3 are more systematic in their approach creating notes or a mental checklist as they assess scripts. Amongst those who have a "checklist" approach most appear to look for the content and level of understanding reflected in the candidate response.

> E2…has looked at the use of anaesthetics treatment of the patient sitting upright and also has discussed that the patient would bring their inhaler to the appointment and that would be close by, and avoid the use of rubber dam to avoid further obstruction of the airway so she has covered some of the main points. I would have liked may be a little more description about asthma to begin with. I do like if they define what it is in a little bit more detail just to show that they understand.

E8 places a greater emphasis on identifying a relevant word. Although s/he uses checklists, E8 does not determine the word's presence, context and the level of understanding in a "tick-box" strategy for marking.

> E8…they've mentioned the possibility of asthma and inverted commas decreased lung function. They actually haven't said that asthmatics should have their inhaler so that should be something that should be mentioned it's not.

There are 5 examiners who are looking for content and evidence of understanding without necessarily being concerned if some elements are missing as long as the scripts reveal higher order skills, whilst the others focus on content, not understanding. Although most examiners summarise the strengths and weaknesses before coming to the final mark, it is not clear how the final mark is determined. For some inexperienced examiners, determination of the higher passing levels is achieved by rigidly adhering to the essay marking guide; however, their consistency in determining this standard seems compromised by not knowing how to assess the additional contextualisation and quality of responses provided by better candidates. These examiners prefer bullet points, where there is less burden, as the volume of text is simpler and limited. When such conflicts arise, the examiners tend to rely on criteria which are not in the essay marking guide or MS, such as sequence of responses and development of argument in the essay.

> E7 It's still ok but still they haven't brought a lot in CBCT aspect, but it's a fairly ok answer. It's got most of the information. Doesn't really have a beginning and an end it's just somebody who has thrown all the information on the paper ….

E7's and E4's discomfort in making judgements is evident in their commentaries as well as in their reluctance to make firm decisions and to compensate for deficiencies in the essay marking guide. The need for professionalism in assessment has recently been noted (11). The lack of clarity on how to proceed and deal with these issues impact on the final mark, and eventually leads to different ways of coping with the percentage scale and essay marking guide that form a poor fit.

> E7…it's very different from that first one. And it's got the same, less than the last one. I'd say it's a very safe pass, 58–59.

It is interesting to note that, E2, an examiner with a post-graduate qualification in education shows a clear understanding of what norm-referencing is, acknowledges that it is inappropriate in criterion-referenced marking, nevertheless E2 employs norm-referencing by ranking candidate's essays. Clearly, the criteria are themselves not enough for E2 who also needs to know how to apply the criteria to establish the standard. Some examiners solve this difficulty by counting the number of correct responses in relation to the essay marking guide before deciding on the grade and mark, rather than considering relevance and importance to the essay.

The more experienced examiners or those with qualifications in education determine the grade first then assign a score, whereas the inexperienced examiners are attempting to assign a score then discover the difficulties of applying a 0–100 range, a point also noted in the literature (10). Although most examiners consider both strengths and weaknesses of a script, there seems to be a focus on omissions when determining the score. Although comparisons are clearly used to rank candidate scripts, they may be advantageous in reducing the possibility of marking harshly (34). There is, in addition, the "halo" effect where if good scripts are encountered after a series of weak scripts, they are given higher marks (35). The sequence of scripts, particularly if they represent extremes, affects examiner marking of subsequent scripts with examiners more likely to link future judgements to initial judgements (36). The differing approaches to handling and applying criteria coupled with an analytic or holistic strategy can only increase the possibility of divergent score assignment thereby adding to the skewing effect. Recently some researchers have proposed using marking parties as a means of reducing the tedium and inconsistency in marking (12).

3.5 Conclusions and recommendations

The purpose of this project is to improve assessment practice in this school, thereby helping to ensure that standards are maintained and that the public is protected. Grade profiles are more useful to learners than a single score, providing them with important clues as to how they can improve their performance. Analytic marking using model answers is prescriptive but facilitates feedback to candidates. However, the time constraints

and the reduction of resources are likely to direct essay assessment to a holistic marking strategy even though this is less helpful to candidates. The greater flexibility inherent in holistic marking is more appropriate in higher education and this marking strategy need not be limiting if the marking employs carefully constructed grade descriptors.

Standards and criteria need to be shared with staff in order to facilitate their internalisation by staff for assessment, and by students for improved future achievement. The assessment paperwork can be modified to complement the assessment process, so that there is correspondence, rather than incongruence, between criteria of the generic MS and the essay marking guides. This can be achieved by linking the generic criteria, and by linking specific criteria to the mark sheets so that the examiners can clearly see how the criteria and standard descriptors are linked. This in itself may be insufficient, and adequate time needs to be invested into assessment to develop and disseminate shared understandings of standards and practice so that the assessment process for a given cohort is valid and reliable. This point, particularly, is important for both inexperienced and experienced examiners as this study shows that experienced examiners can themselves skew results with their individualised sets of criteria.

Essays are creative pieces of work. No essay plan or model answer can anticipate the range of candidate responses; often the responses will not fit neatly into the categories created by the examiner. This problem can to some extent be alleviated by using exemplars to illustrate the standards in combination with the establishment of a consensual standard in academic communities. Without discussion about standards and exemplars to help in score assignment, the examiners simply resort to ranking, as they do in this study, giving secondary consideration to the percentage scale. The consequence is a narrower range of marks not employing the full scale.

Whilst this study has elucidated problematic issues in assigning scores, it has also uncovered areas which deserve further attention, including how examiners respond to essays emotionally and to essays of differing lengths; psychological aspects of judgements in essay marking; how positivistic or other philosophical stances influence marking; exploration of how other assessment scales can improve reliability in essays marking. In order to address the pressure on educators, examiners, and institutions, further study of these issues will raise the level of accountability, transparency, and consistency of the assessment process and help to provide assurance of reliable assessments. There is a need to study these issues further as well as how assessment process validity can be enhanced by helping assessors develop a shared understanding using a holistic approach with grade descriptors and exemplars.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Informed consent was obtained from all participants. Participant identity is protected by anonymising the audio-tapes and coding any names in transcripts. The identity of students and staff is protected by using codes in the exam results. No year is indicated in the tabulated results, so that neither staff nor candidates from the cohort can be identified from tables of results. Ethical approval was obtained to carry out this study from King's College London (BDM/09/10-83) and from the Director of Education.

Author contributions

AH: Conceptualization, Formal Analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. BJ: Formal Analysis, Writing – original draft, Writing – review & editing.

Funding

The authors declare that no financial support was received for the research, authorship, and/or publication of this article.

Acknowledgments

This article is based on a project submitted by AH for the degree of MA in Academic Practice. We are grateful to Sharon Markless for her critique of this paper.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

1. Caspersen J, Smeby J-C, Aamodt PO. Measuring learning outcomes. *Eur J Educ*. (2017) 52(1):20–30. doi: 10.1111/ejed.12205

2. Tomlinson M. Student perceptions of themselves as "consumers" of higher education. *Br J Sociol Educ* . (2017) 38(4):450–67. doi: 10.1080/01425692.2015.1113856

3. Gipps C. *Beyond Testing: Towards a Theory of Educational Assessment*. London: Routledge (1994).

4. Palmer EJ, Devitt PG. Assessment of higher order cognitive skills in undergraduate education: modified essay or multiple choice questions? Research paper. *BMC Med Educ* . (2007) 7(1):49. doi: 10.1186/1472-6920-7-49

5. De Cossart L, Fish D. *Cultivating a Thinking Surgeon: New Perspectives on Clinical Teaching, Learning and Assessment*. Harley: TFM Publishing (2005).

6. Biggs J. What do inventories of students' learning processes really measure? A theoretical review and clarification. *Br J Educ Psychol*. (1993) 63(1):3–19. doi: 10.1111/j.2044-8279.1993.tb01038.x

7. Ecclestone K. 'I know a 2:1 when I see it': understanding criteria for degree classifications in franchised university programmes. *J Furth High Educ*. (2001) 25 (3):301–13. doi: 10.1080/03098770126527

8. Price M. Assessment standards: the role of communities of practice and the scholarship of assessment. *Assess Eval High Edu*. (2005) 30(3):215–30. doi: 10.1080/02602930500063793

9. Bloxham S. Marking and moderation in the UK: false assumptions and wasted resources. *Assess Eval High Edu*. (2009) 34(2):209–20. doi: 10.1080/02602930801955978

10. Handley FJL, Read A. Developing assessment policy and evaluating practice: a case study of the introduction of a new marking scheme. *Perspect: Policy Pract High Educ*. (2017) 21(4):135–9. doi: 10.1080/13603108.2015.1128490

11. Norton L, Floyd S, Norton B. Lecturers' views of assessment design, marking and feedback in higher education: a case for professionalisation? *Assess Eval High Educ* . (2019) 44(8):1209–21. doi: 10.1080/02602938.2019.1592110

12. Vaccari E, Moonen-van Loon J, Van der Vleuten C, Hunt P, McManus B. Marking parties for marking written assessments: a spontaneous community of practice. *Med Teach*. (2023) 46:1–7. doi: 10.1080/0142159X.2023.2262102

13. Wood R. *Assessment and Testing: A Survey of Research Commissioned by University of Cambridge Local Examinations Syndicate*. Cambridge: Cambridge University Press (1991).

14. Brown A, Campione J, Webber L, McGilly K. Interactive learning environments: a new look at a assessment and instruction. In: Gifford BR, O'Connor MC, editors. *Changing Assessments: Alternative Views of Aptitude, Achievement and Instruction*. New York: Kluwer Academic Pub (1992). p. 77–166.

15. Shavelson RJ, Baxter GP, Pine J. Performance assessments: political rhetoric and measurement reality. *Educ Res*. (1992) 21(4):22–7.

16. Breland H. From 2 to 3Rs: the expanding use of writing in admissions. In: Messick SJ, editor. *Assessment in Higher Education: Issues of Access, Quality, Student Development, and Public Policy*. New York: Lawrence Erlbaum (1999). p. 91–112.

17. Bloxham S, Boyd P. *Developing Effective Assessment in Higher Education: A Practical Guide*. Maidenhead: Open University Press (2007).

18. NSS. National Student Survey – NSS. Available online at: https://www.officeforstudents.org.uk/advice-and-guidance/student-information-and-data/national-student-survey-nss/ (Accessed June 01, 2023).

19. Denzin NKLYS. *The Sage Handbook of Qualitative Research*. London: Sage (2011).

20. Roth W-M, Middleton D. Knowing what you tell, telling what you know: uncertainty and asymmetries of meaning in interpreting graphical data. *Cult Stud Sci Educ*. (2006) 1(1):11–81. doi: 10.1007/s11422-005-9000-y

21. Cohen L, Manion L, Morrison K. *Research Methods in Education*. London: Routledge, Taylor & Francis Group (2018).

22. Charmaz C. Grounded theory: objectivist and constructivist methods. In: Denzin NK, Lincoln Y, editors. *The Handbook of Qualitative Research*. Thousand Oaks: Sage Publications (2000). p. 509–35.

23. Miles M, Huberman A. *Qualitative Data Analysis: An Expanded Sourcebook*. Thousand Oaks: SAGE publications, Inc (1994).

24. Knight PT. Summative assessment in higher education: practices in disarray. *Stud High Educ*. (2002) 27(3):275–86. doi: 10.1080/03075070220000662

25. Hasan A. *Summative assessment skews candidate scores and grades* (MA master of arts degree, King's college London). University of London (2009).

26. Price M, Rust C. The experience of introducing a common criteria assessment grid across an academic department. *Qual High Educ*. (1999) 5(2):133–44. doi: 10.1080/1353832990050204

27. Quality Assurance Agency. A map of the standards and guidelines for quality assurance in the European higher education area to the UK quality code for higher education (2023). Available online at: https://www.qaa.ac.uk/docs/qaa/quality-code/map-of-esg-to-quality-code.pdf?sfvrsn=7503a081_6 (Accessed July 10, 2023).

28. Yorke M, Bridges P, Woolf H. Mark distributions and marking practices in UK higher education: some challenging issues. *Act Learn High Educ*. (2000) 1(1):7–27. doi: 10.1177/1469787400001001002

29. Crisp V. Exploring the nature of examiner thinking during the process of examination marking. *Camb J Educ*. (2008) 38(2):247–64. doi: 10.1080/03057640802063486

30. Lumley T. Assessment criteria in a large-scale writing test: what do they really mean to the raters? *Lang Test*. (2002) 19(3):246–76. doi: 10.1191/0265532202lt230oa

31. Sadler DR. Interpretations of criteria-based assessment and grading in higher education. *Assess Eval High Edu*. (2005) 30(2):175–94. doi: 10.1080/0260293042000264262

32. Baume D, Yorke M, Coffey M. What is happening when we assess, and how can we use our understanding of this to improve assessment? *Assess Eval High Edu*. (2004) 29(4):451. doi: 10.1080/02602930310001689037

33. Goldstein H. Assessing group differences. *Oxf Rev Educ*. (1993) 19(2):141–50. doi: 10.1080/0305498930190202

34. Laming DRJ. *Human Judgment: The eye of the Beholder*. London: Thomson Learning (2004).

35. Spear M. The influence of contrast effects upon teachers' marks. *Educ Res*. (1997) 39(2):229–33. doi: 10.1080/0013188970390209

36. Tversky A, Kahneman D. Judgment under uncertainty: heuristics and biases. *Science*. (1974) 185(4157):1124–31. doi: 10.1126/science.185.4157.1124

frontiers | Frontiers in Medicine

TYPE Original Research
PUBLISHED 30 May 2024
DOI 10.3389/fmed.2024.1306205

OPEN ACCESS

EDITED BY
Melanie Nasseripour,
King's College London, United Kingdom

REVIEWED BY
Khalid M. Alshamrani,
King Saud bin Abdulaziz University for Health Sciences, Saudi Arabia
Angelo Leone,
University of Palermo, Italy
Pinsuda Srisontisuk,
King's College London, United Kingdom

*CORRESPONDENCE
Shoroog Agou
✉ sagou@kau.edu.sa

RECEIVED 03 October 2023
ACCEPTED 06 May 2024
PUBLISHED 30 May 2024

CITATION
Zahid TM and Agou S (2024) E-learning readiness among dental students and faculty: a comparative study before and after the COVID-19 pandemic.
Front. Med. 11:1306205.
doi: 10.3389/fmed.2024.1306205

E-learning readiness among dental students and faculty: a comparative study before and after the COVID-19 pandemic

Talal M. Zahid[1] and Shoroog Agou[2]*

[1]Department of Periodontology, Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia, [2]Department of Orthodontics, Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia

Background: The COVID-19 pandemic accelerated the global adoption of e-learning, even in institutions that had previous reservations. Nevertheless, the impact of this transformation on dental education remains unclear. This study aimed to assess the e-learning readiness of dental students and faculty before and after COVID-19. It also explored their post-pandemic e-learning preferences for dental education.

Methods: Cross-sectional surveys were conducted at King Abdulaziz University's Faculty of Dentistry (KAUFD) in Jeddah, Saudi Arabia both before and after COVID-19. Faculty and students from two distinct cohorts were recruited at two time points. Participants completed a detailed questionnaire on e-learning readiness across multiple domains. Statistical analysis was performed using R v 3.6.3. Descriptive and group comparisons were conducted using chi-squared test, unpaired *t*-test, and Spearman's correlation.

Results: 1,057 responses (response rate = 99.8%) were analyzed: 2015 ($n = 400$) and 2021 ($n = 657$). Both faculty and students demonstrated significant improvements in e-learning readiness across all domains from 2015 to 2021. In 2021, faculty members scored significantly higher than students in almost all readiness domains, except for e-learning experience ($p < 0.001$ for all domains). After the pandemic, both groups preferred a blended learning model: 75% traditional and 25% online education. A significant increase in typing and editing training requests by faculty and students was observed in 2021. Students showed a decline in training needs for web and online tool usage.

Conclusion: The COVID-19 pandemic pushed the rapid adoption of e-learning in dental education. In this study, faculty showed greater e-learning readiness, but students voiced concerns about missed in-person interactions, social isolation, and screen fatigue. Further multi-institutional studies are required for more comprehensive insights.

KEYWORDS

dental education, e-learning, COVID-19, e-learning preferences post pandemic, online learning, e-learning readiness

Introduction

E-learning is learning utilizing formalized teachings but with the help of digital tools, typically via the internet. E-learning readiness, on the other hand, refers to the preparedness of an institution, organization, or a person to engage in e-learning activities (1). E-learning has evolved as an effective method of education for distance learners over the last 20 years (2, 3). While ongoing research is being conducted on the application of e-learning in educational settings, studies published to date suggest its certain advantages over conventional educational methods (2–7). The noted advantages of using e-learning include lower cost, more flexibility and versatility, and easier access. In fact, e-learning can address some of the common problems in the traditional education system. These may include faculty member shortages, limited resource accessibility, and inadequate classroom space (2, 3, 5). Moreover, a growing body of studies now suggests e-learning as an inclusive mode of education that caters to various learning styles (5–9).

After the COVID-19 outbreak in 2019, e-learning overnight became the primary mode of education for millions of students across the globe. Higher education institutions were forced to adopt digital platforms and transition to online learning at an unprecedented scale (9). This abrupt shift from onsite to remote education occurred even though the efficacy of online teaching and learning had not been thoroughly studied under similar circumstances (4, 6, 8–10). As a result, despite insufficient evidence, universities and colleges worldwide incorporated e-learning into their curricula to continue teaching activities. This sudden change has actually accelerated the adoption of e-learning approaches, overcoming previous resistances (4, 9, 10). However, the effects of this change on dental school students and faculty remain uncertain. Hence, there is a need to assess e-learning success factors to create effective online learning methods and maintain such advancements in the future.

In recent years, the Kingdom of Saudi Arabia has taken numerous initiatives to implement sustainable e-learning strategies, including in the field of dental education. The nation has acknowledged the significance of implementing top-notch educational practices in line with the demands of globalization to meet upcoming challenges (9, 11, 12). Accordingly, the Faculty of Dentistry at King Abdulaziz University (KAUFD) incorporated e-learning strategies in its curriculum to raise the standard of online teaching and learning. This incorporation, however, happened long before the COVID-19 pandemic hit the world (8, 13).

Before the pandemic, a study conducted at KAUFD assessed the readiness of students and faculty for online dental education. It revealed that while students exhibited acceptable levels of personal traits and system competency, their readiness for e-learning decreased with age (12). However, it should be noted that KAUFD introduced its first structured e-learning program only after the pandemic hit. A study was conducted afterward to measure the perceptions and overall experiences of dental students using the structured program (8). The results indicated that students had a favorable view of e-learning in terms of its value, usability, and opportunity for self-reflection. However, the study was subjected to biases due to its use of a convenience sampling technique and a low response rate, which limits the generalizability of the results. Hence, there is a need for more comprehensive studies to effectively evaluate e-learning necessities in dental education.

Therefore, the aim of this study was to investigate the readiness of dental students and faculty members at KAUFD toward e-learning, specifically online teaching and learning, both before and after the COVID-19 pandemic. Additionally, we aimed to explore post-pandemic e-learning preferences in order to plan for a meaningful and effective integration of e-learning modalities in dental education.

Materials and methods

Research design

A comparative cross-sectional survey was conducted at KAUFD in Jeddah, Saudi Arabia to explore the readiness of dental students and faculty to adopt e-learning for online teaching and learning. This study involved two time points, at each time point, students studying at KAUFD were evaluated. Hence, the two time points represent two cohorts of students. The Institutional Review Board at KAUFD reviewed and approved this study. Informed consent was obtained from all participants before the study began.

Sample selection

We approached two distinct cohorts of faculty and students attending KAUFD at two different time points: before the onset of the COVID-19 pandemic (in 2015) and in the post-pandemic era (in 2022). Initially, we aimed for a total sample approach, intending to include all members of these cohorts. However, our sampling method aligned more closely with convenience sampling due to practical constraints. We recruited all subjects who agreed to participate. This approach provided a representative snapshot of the attitudes and experiences of participants within our institution during these periods.

Data collection

We created the questionnaire using Google Forms and distributed it to students and faculty via email. Follow-up reminders were sent 2 weeks and 1 month after the initial email. Participants were asked to complete the questionnaire by scanning the QR code with their smartphones or tablets. This same recruitment process was employed for cohorts of both time points.

Questionnaire design

The primary objective of this study was to explore the readiness of dental students and faculty to adopt e-learning for online teaching and learning. The study used a theoretical model, similar to the ones proposed and validated by Al-Harbi (14, 15) and Cidral et al. (16) that included constructs and relationships of factors that influence e-learning readiness. These constructs are categorized into four basic domains: (1) individual characteristics, (2) system competency requirements, (3) social influence, and (4) institutional support. Linjawi et al. (12) also adopted this model in a similar population.

Based on the questionnaire model developed by Al-Harbi (14, 15), we adopted their questionnaire to assess the readiness of students and faculty members on e-learning and carefully fitted it to the unique requirements of our current investigation while also adding elements from earlier research (12, 16). The questionnaire was reviewed by two

doctorate of philosophy (PhD) degree holder with extensive experience in biostatistics. The questionnaire had a total of 36 questions: 31 questions on e-learning readiness using a five-point Likert scale (17), one question on experience, one question addressing challenges, one question regarding needed support, and two global questions. The domains were designed as follows.

Individual characteristics domain

- *Demographics*: This subdomain included questions on age, gender, and grade. For faculty members, four additional questions were asked, including the subject they teach, their degree and the university they graduated from, the location and year it was obtained, and years of teaching experience.
- *Computer skills*: This subdomain designed to evaluate the participants' computer proficiency. Topics covered in the questions included operating a computer, installing or setting up software, writing and editing using Office applications, formatting documents, managing multimedia files, and ability to multitask with multiple open windows.
- *E-learning experience*: This subdomain assessed participants' experience and participation in e-learning activities, such as online courses, discussions, exams, and workshops.

System competency needs domain (multiple Likert scale-based questions)

a. *Perceived ease of use*: this subdomain analyzed participants' perceptions of online tool usage for personal and educational purposes. It consisted of the following:

   i. *Online skills:* assessed participants' perceived abilities in using various online services and tools such as searching information on the internet, sending and receiving emails, downloading and uploading files, and engaging with social media platforms.
   ii. *Motivation level:* evaluated participants' perceived motivation when tackling extensive online tasks independently, such as staying focused during online lectures, completing online tasks despite distractions, dedicating 10–20 h per week to online lectures, and setting specific goals and deadlines.
   iii. *English literacy*: assessed participants' perceived level of proficiency in online communication, particularly in overcoming language barriers.

b. *Perceived usefulness*: this subdomain investigated the following two variables:
   i. *Importance of online technology* for success in both personal and educational contexts.
   ii. *Impact of e-learning on dental education.*

c. *Technology accessibility*: this subdomain evaluated the availability of all necessary technological resources for e-learning implementation, such as hardware, software, internet connectivity, and mobile devices.

Social influence domain or social norms

Social influence domain or social norms assessed the influence of surrounding people (e.g., friends, family members, and educators) on participants' perception and use of online services.

Institutional support domain

Institutional support domain analyzed the significance of technical and administrative institutional support for the successful adoption of e-learning in dental education.

Overall readiness domain

Overall readiness domain evaluated participants' overall readiness for adopting e-learning in dental education.

Needed technical support domain

Needed technical support domain assessed whether the participants need technical support to adopt e-learning strategies in dental education.

Open-ended questions

There were also two open-ended questions at the end of the questionnaire. The first question was designed to explore participants' thoughts on potential challenges and concerns in adopting e-learning in dental education. The second question sought solutions and recommendations for overcoming these challenges.

Supplemental questionnaire

The same questionnaire was distributed in 2015 and 2021. In the 2015 questionnaire, however, questions related to English literacy, perceived usefulness, social influence, and institutional support were excluded for students, as they were considered more pertinent to faculty members. In contrast, both groups received the same set of questions in the 2021 questionnaire.

The 2021 questionnaire also included a supplemental section, which comprised a total of eight questions. Four questions explored the pandemic's impact on e-learning using a five-point Likert scale; one question addressed post-pandemic preferences; one assessed learning quality; and two open-ended questions focused on challenges and solutions. Specific topics covered included opinions on the effects of COVID-19 on readiness, the online learning environment, study plans and learning goals, encountered difficulties, time management, and overall learning experience. Participants were also asked about their transition back to regular life activities and the quality of online learning experiences in the university. The appendix section includes a detailed questionnaire, along with the individual questions.

Statistical analysis

Statistical Analysis was performed using R v 3.6.3. Counts and percentages were used to summarize categorical variables. The mean ± standard deviation (SD) and the median/interquartile range (IQR) were used for continuous normal and non-normal variables, respectively. Unpaired *t*-test was used to compare continuous variables between groups, and the Chi-square test was used for categorical variables. Spearman's correlation was used to assess the association between continuous variables. Hypothesis testing was performed at 5% level of significance. The percentage (%) of readiness was calculated by dividing the readiness score by the maximum possible score.

Results

The total response rate was 99.8% ($n = 1059/1061$). Two questionnaires were excluded due to missing major data, representing only 0.1% of responses. A total of 1,057 responses were included; of these, 400 responses were from 2015 (faculty members, $n = 50$; students, $n = 350$), while 657 responses were from 2021 (faculty members, $n = 201$; students, $n = 456$).

Sample characteristics

The mean age of faculty members was 42 years in 2015 and 40 years in 2021. The mean age of students was 24 years in 2015 and 22 years in 2021 (Table 1). There was no significant difference in gender distribution between the two groups, with a p value of 0.071.

Assessment of e-learning readiness across domains

Results showed that both faculty and students experienced statistically significant improvements in almost all domains of e-learning readiness between 2015 and 2021 (Table 2). In the post-COVID-19 period, both faculty and students demonstrated significant improvements in technological access, with faculty's mean score increasing from 4.36 to 4.65 ($p < 0.001$) and students' mean score from 4.04 to 4.21 ($p < 0.001$). This indicates better technological access for both groups in 2021 compared to 2015. A similar pattern was noted in computer skills, online skills, motivation level, and overall readiness variables. However, unlike the results observed in faculty members for the computer skills subdomain, no significant difference was seen in students between pre-and post-COVID-19 periods ($p = 0.122$).

Several variables remained relatively stable for faculty members, including English literacy (from 4.56 to 4.59, $p = 0.048$), institutional support (from 4.56 to 4.55, $p = 0.193$), and perceived usefulness in terms of importance (from 4.56 to 4.66, $p = 0.480$). A decline was observed in e-learning experience after the pandemic for both faculty members (from 2.86 to 2.67, $p = 0.784$) and students (from 3.81 to 3.51, $p < 0.001$).

Faculty members vs. students

The mean score for all domains was significantly higher in faculty members than in students, except for the e-learning experience score, which was higher in students. All comparisons were statistically significant at the 0.001 level (Table 2).

Overall readiness and perception

The analysis of 2021 supplemental questionnaire revealed a significant difference between students and faculty members in terms of preparedness for online learning, with faculty members showing a higher level of readiness ($p < 0.001$) (Table 2). Among faculty members, two-thirds strongly agreed that the pandemic had improved their online teaching readiness, while only one-quarter of the students felt the same way ($p < 0.001$) (Table 3). When asked about their preferences if normal life activities were to resume, the majority of both groups still favored a mix of traditional and online education ($p = 0.001$). The largest percentage of students (27.4%) and the majority of faculty (39.3%) preferred a mix of 75% traditional and 25% online education. Faculty members also rated the quality of the online learning experience significantly higher than students did ($p < 0.001$).

Extra training requests

Between 2015 and 2021, faculty members experienced a significant increase in requests for training in typing and editing (from 16.0 to 40.9%, $p = 0.002$) and time management (from 10.0 to 41.5%, $p < 0.001$), while demand for designing online content significantly decreased (from 58.0 to 27.7%, $p < 0.001$) (Figure 1). For students, a significant increase in requests for typing and editing training was observed (from 31.4 to 45.0%, $p < 0.001$), whereas the need for training in using the web for education (from 51.7 to 31.4%, $p < 0.001$) and using online tools in education (from 51.4 to 38.6%, $p < 0.001$) significantly declined during the same period.

Discussion

The COVID-19 pandemic has caused a paradigm shift in education. It forced both teachers and students to move from in-person classrooms to digital platforms. They had a totally different experience due to this shift in learning approach. The present study aimed to investigate the readiness of faculty and students toward online teaching and learning both before and after the COVID-19 pandemic. The study also explored post-pandemic preferences of both groups to effectively incorporate e-learning into dental education.

TABLE 1 Demographics of the study sample (stratified by year and group).

		Faculty 2015 ($n = 50$)	Faculty 2021 ($n = 201$)	Student 2015 ($n = 350$)	Student 2021 ($n = 456$)
Age	Mean (SD)	42.5 (11.6)	39.7 (9.02)	24.2 (2.85)	22.3 (1.57)
Gender					
Male	*n* (%)	28 (56.0%)	100 (49.8%)	202 (57.7%)	223 (48.9%)
Female	*n* (%)	22 (44.0%)	101 (50.2%)	148 (42.3%)	233 (51.1%)

SD, Standard deviation.

TABLE 2 Distribution of scores for the study constructs across students and faculty members (stratified by year).

Domain	Variables	Faculty 2015[a] *Mean (SD)*	Faculty 2021[b] *Mean (SD)*	Students 2015[c] *Mean (SD)*	Students 2021[d] *Mean (SD)*	*p* (F2015 vs. F2021)	*p* (F2015 vs. S2015)	*p* (F2021 vs. S2021)	*p* (S2015 vs. S2021)	Faculty overall *(n = 251)*	Student overall *(n = 806)*	*p* (overall)
Individual characteristics domain	Computer skills	4.25 (0.64)	4.46 (0.63)	4.07 (0.66)	4.10 (0.80)	0.015*[ab]	0.093	<0.001*[bd]	0.122	4.42 (0.63)	4.09 (0.74)	<0.001*
	E-learning experience	2.86 (1.26)	2.67 (1.49)	3.81 (0.66)	3.51 (0.73)	0.784	<0.001*[ac]	<0.001*[bd]	<0.001*[cd]	2.71 (1.45)	3.64 (0.71)	<0.001*
System competency domain	*Perceived ease of use*											
	Online skills	3.97 (0.83)	4.58 (0.39)	4.00 (0.80)	4.21 (0.74)	<0.001*[ab]	0.816	<0.001*[bd]	<0.001*[cd]	4.46 (0.56)	4.12 (0.77)	<0.001*
	Motivation level	3.82 (0.72)	4.52 (0.47)	3.52 (0.77)	3.87 (0.82)	<0.001*[ab]	0.004*[ac]	<0.001*[bd]	<0.001*[cd]	4.38 (0.60)	3.72 (0.82)	<0.001*
	English literacy	4.56 (1.05)	4.59 (0.51)	NA	4.12 (1.06)	0.048*[ab]	NA	<0.001*[bd]	NA	4.58 (0.65)	4.12 (1.06)	<0.001*
	Perceived usefulness											
	Perceived usefulness—importance	4.56 (0.64)	4.66 (0.49)	NA	4.33 (0.77)	0.480	NA	<0.001*[bd]	NA	4.64 (0.52)	4.33 (0.77)	<0.001*
	Perceived usefulness—impact	4.26 (0.56)	4.38 (0.74)	4.04 (0.85)	3.76 (1.12)	0.077	0.166	<0.001*[bd]	0.007*[cd]	4.36 (0.71)	3.88 (1.02)	<0.001*
	Technology accessibility											
	Technological access	4.36 (0.55)	4.65 (0.36)	4.04 (0.69)	4.21 (0.63)	<0.001*[ab]	0.001*[ac]	<0.001*[bd]	<0.001*[cd]	4.59 (0.42)	4.14 (0.67)	<0.001*
Social influence	Social influence	3.99 (0.98)	4.51 (0.48)	NA	4.01 (0.86)	0.001*[ab]	NA	<0.001*[bd]	NA	4.41 (0.65)	4.01 (0.86)	<0.001*
Institutional support	Institutional support	4.56 (0.81)	4.55 (0.51)	NA	4.14 (0.93)	0.193	NA	< 0.001*[bd]	NA	4.55 (0.58)	4.14 (0.93)	<0.001*
Overall readiness	Overall readiness (%)	78.0 (16.8)	88.9 (14.5)	69.2 (21.3)	75.9 (21.1)	<0.001*[ab]	0.005*[ac]	<0.001*[bd]	<0.001*[cd]	--	--	--

NA, Not applicable. Analysis was performed using one-way ANOVA for the overall association and using unpaired *t*-test with Tukey's adjustment for pairwise comparisons.

*$p < 0.05$ indicates statistical significance, symbols a, b, c, and d represent the mean scores for Faculty 2015, Faculty 2021, Students 2015, and Students 2021, respectively. Combined symbols (e.g., ab) indicate a significant difference between the groups (e.g., Faculty 2015 vs. Faculty 2021).

10.3389/fmed.2024.1306205

TABLE 3 Overall readiness and perception toward online teaching and learning in 2021.

	Faculty	Student	*p* (overall)
	n = 201	*n* = 453	
Overall, I think I was well-prepared for online teaching/learning:			<0.001*
- Strongly disagree	1 (0.50%)	41 (9.05%)	
- Disagree	6 (2.99%)	54 (11.9%)	
- Neutral	9 (4.48%)	104 (23.0%)	
- Agree	91 (45.3%)	143 (31.6%)	
- Strongly agree	94 (46.8%)	111 (24.5%)	
I believe the COVID-19 pandemic experience has improved my online teaching/learning readiness:			<0.001*
- Strongly disagree	0 (0.00%)	38 (8.39%)	
- Disagree	0 (0.00%)	53 (11.7%)	
- Neutral	9 (4.48%)	98 (21.6%)	
- Agree	59 (29.4%)	145 (32.0%)	
- Strongly agree	133 (66.2%)	119 (26.3%)	
If we were to go back to normal life activities, I would prefer to:			0.001*
- Traditional face-to-face 100%	22 (10.9%)	66 (14.6%)	
- Traditional face-to-face 75%	79 (39.3%)	124 (27.4%)	
- Traditional face-to-face 50%	29 (14.4%)	123 (27.2%)	
- Traditional face-to-face 25%	60 (29.9%)	114 (25.2%)	
- Online learning 100%	11 (5.47%)	26 (5.74%)	
Overall perception regarding the quality of online learning experience	9.00 [9.00;10.0]	8.00 [7.00;9.00]	<0.001*

Counts and percentages were used to summarize categorical data, and the median [IQR] was used to summarize continuous data. Continuous data were compared using the Mann–Whitney test, while categorical data were compared using the Chi-square test of independence. A *p* value of less than 0.05 was considered statistically significant. The asterisk () indicates a *p* value of less than 0.05.

The results of this study revealed significant improvements in various domains of e-learning readiness between 2015 and 2021 among both faculty members and students. In the post-pandemic period, there was a notable increase in the overall readiness score for faculty members, indicating a positive trend in the adoption of online teaching and learning methods. Similarly, students' overall readiness also improved during the same period. These results could be attributed to the extensive use of online learning tools and platforms due to the COVID-19 pandemic, which forced educational institutions to adapt to remote learning methods (4, 6, 8).

In this study, however, we also observed significant differences in the readiness and perception scores between faculty and students. Faculty members had higher scores in almost all domains than students. They also rated their quality of online learning experience higher than students. The only subdomain in which students had an edge was e-learning activities and involvement. It is possible that faculty members either found it easier or were under more pressure to adapt to the remote learning environment than students due to their responsibility to teach and role as content creators (18, 19). In fact, they also had an increased exposure to online teaching tools and resources during the pandemic (10, 13, 18).

In contrast, we observed that students were comparatively less engaged with e-learning than faculty. Indeed, in their responses to open-ended questions, students explicitly mentioned several challenges as barriers to fully adapting to the e-learning environment, including lack of in-person interactions, difficulty communicating with instructors, social media distractions, prolonged screen time, technical difficulties, and time management. One student actually reported that his ability to grasp concepts during e-learning session is significantly reduced compared to face-to-face instruction. These concerns align with previous studies that have identified similar challenges faced by students in e-learning environments (20–22). In fact, prior literature has shown that prolonged engagement with online platforms can lead to e-learning fatigue, which affects both faculty and students (22–26). Taken together, the presence of these barriers might contribute to students feeling less engaged, leading to a lesser perceived quality of online learning.

Furthermore, Vygotsky's social constructivist theory emphasizes that learning is fundamentally a social process, deeply influenced by interaction within a cultural context (27, 28).

This perspective is particularly relevant as students experienced significant social isolation during the lockdown, impacting their mental well-being and potentially reducing their motivation to engage with e-learning platforms (21, 22, 24, 29). Such isolation likely contributed to students' expressed preferences for learning models that are more interactive and socially engaging. It underscores the critical need for e-learning platforms to address not only the academic requirements of students but also their psychological well-being (29). In our study, students suggested effective scheduling and opening the cameras as solutions to deal with these barriers.

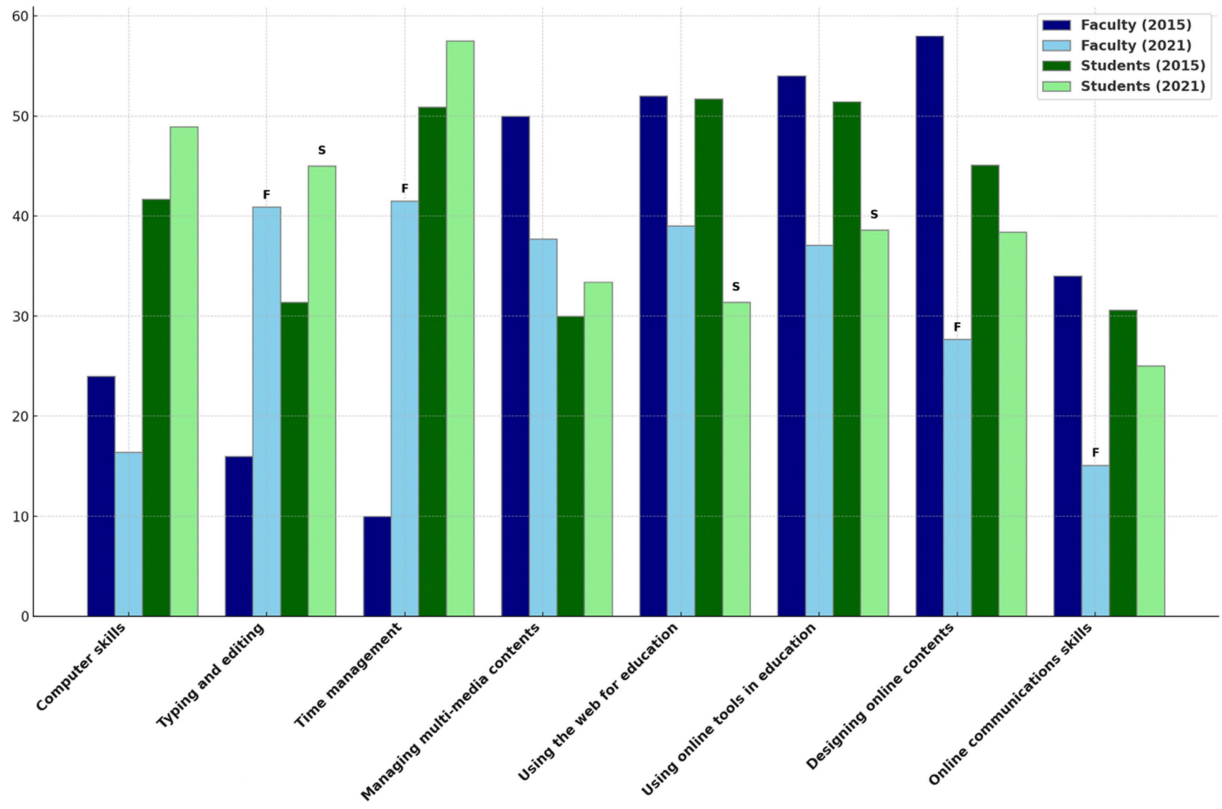

FIGURE 1
Comparison of training needs in technology use: Faculty vs. Students (2015 vs. 2021). The graph illustrates the percentage of faculty and students who reported a need for additional training in various technology use categories in 2015 and 2021. Symbols "F" and "S" above the bars represent statistically significant changes over the years for faculty and students, respectively, with a *p* value less than 0.05 indicating a significant difference in reported training needs between the 2 years.

Taken together, it can be said that the COVID-19 pandemic brought several lessons to the forefront for dental schools. Dental schools can use e-learning to provide students with access to a broader range of learning resources, including virtual simulations, online textbooks, and interactive multimedia content (2, 3). Additionally, e-learning can help to overcome some of the challenges associated with traditional teaching methods, such as limited access to clinical training and the high cost of materials (5–9). However, there is also a need to consider the limitations of e-learning. Given students' difficulties with feelings of isolation and time management, dental schools need to work on developing a more engaging and interactive online learning environment that rationally blends both online and face-to-face instructions. Incorporating elements like group discussions, peer interactions, and virtual patient cases might capture the collaborative spirit of in-person learning (4, 10, 16). Moreover, adopting a flipped classroom design, where students acquire the didactic part before class, and face-to-face sessions are saved for higher order thinking and psychomotor skills might be a better model for dental schools to adopt.

The majority of students and faculty believe the pandemic has significantly improved their e-learning readiness, supporting the general notion that COVID-19 has accelerated the e-learning learning curve. That said, there is plenty of room for institutional support to improve the e-learning experience for faculty and students. In our study, students and faculty requested support in enhancing their skills like time management, typing and editing, using AI tools for education, and general computing skills among many other skills.

Limitations, recommendations for practice and future studies

This study presents several limitations. Since our research was based on data from a single dental school (i.e., KAUFD), the findings of this study are not generalizable. Another limitation was relying solely on digital platforms to reach out participants. This meant we missed out on the depth and subtlety that face-to-face interviews could bring. We also relied on total sample approach because of time constraints. This choice might have limited the generalizability of the results. Finally, although the Likert scale questions streamlined the responses, this might have restricted the depth of insights that other questioning techniques could have uncovered.

Moving forward, future studies should explore the effects of e-learning on student's overall performances. By comparing our data with other dental schools and health institutions, a more

comprehensive understanding can be gained on this. Dental schools should thus continue investing in e-learning to better evaluate its efficacy and acceptance. Long-term studies evaluating e-learning challenges are needed to reap the full advantages of e-learning. Additionally, to ensure the generalizability of the results, these studies should also include students from various disciplines across Saudi universities.

Conclusion

The COVID-19 pandemic has accelerated the adoption of e-learning in dental education, revealing both its advantages and drawbacks. While faculty members have showed more readiness to e-learning, students expressed concerns, particularly around social isolation, screen fatigue, and the lack of in-person interactions. Hence, it is important to ensure that e-learning platforms also cater to students' social and psychological needs. While findings from our single-school study provide valuable insights, a broader examination across multiple institutions is required for a comprehensive understanding. Therefore, dental schools should continue their investment in e-learning to shape a balanced and effective educational future.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The Institutional Review Board at KAUFD reviewed and approved this study (Protocol# 147-12-20). We obtained a written informed consent from all participants before the study began.

Author contributions

TZ: Data curation, Formal analysis, Methodology, Resources, Software, Visualization, Writing – original draft, Writing – review & editing. SA: Conceptualization, Data curation, Formal analysis, Methodology, Resources, Supervision, Visualization, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Acknowledgments

The authors extend their gratitude to Prof. Amal Linjawi, Dr. Esra Sahhab, Dr. Jehad Turkistani, and Dr. Horia Alghanmi for their invaluable assistance with this project.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

1. Hashim H, Tasir Z. E-learning readiness: A literature review. 2014 international conference on teaching and learning in computing and engineering. (2014) 267–271.

2. Zitzmann NU, Matthisson L, Ohla H, Joda T. Digital undergraduate education in dentistry: a systematic review. *Int J Environ Res Public Health*. (2020) 17:1–23. doi: 10.3390/ijerph17093269

3. Vaona A, Banzi R, Kwag KH, Rigon G, Cereda D, Pecoraro V, et al. E-learning for health professionals. *Cochrane Database Syst Rev*. (2018) 1:CD011736. doi: 10.1002/14651858.CD011736.pub2

4. Naciri A, Radid M, Kharbach A, Chemsi G. E-learning in health professions education during the Covid-19 pandemic: a systematic review. *J Educ Eval Health Prof*. (2021) 18:27. doi: 10.3352/jeehp.2021.18.27

5. Soltanimehr E, Bahrampour E, Imani MM, Rahimi F, Almasi B, Moattari M. Effect of virtual versus traditional education on theoretical knowledge and reporting skills of dental students in radiographic interpretation of bony lesions of the jaw. *BMC Med Educ*. (2019) 19:233. doi: 10.1186/s12909-019-1649-0

6. Mc CJA, Bhimagani L, Ys N, Sj L, Kunchapu M. E-learning vs conventional teaching among students during covid-19 pandemic in India. *Bioinformation*. (2022) 18:1005–8. doi: 10.6026/973206300181005

7. Voutilainen A, Saaranen T, Sormunen M. Conventional vs. E-learning in nursing education: a systematic review and meta-analysis. *Nurse Educ Today*. (2017) 50:97–103. doi: 10.1016/j.nedt.2016.12.020

8. Bahanan L, Alsharif M, Samman M. Dental dtudents' perception of integrating E-learning during Covid-19: a cross-sectional study in a Saudi university. *Adv Med Educ Pract*. (2022) 13:839–47. doi: 10.2147/AMEP.S376069

9. Al-Kahtani N. A survey assessing the health science Students' perception towards online learning at a Saudi higher education institution during Covid-19 pandemic. *Heliyon*. (2022) 8:e10632. doi: 10.1016/j.heliyon.2022.e10632

10. Zalat MM, Hamed MS, Bolbol SA. The experiences, challenges, and acceptance of E-learning as a tool for teaching during the Covid-19 pandemic among university medical staff. *PLoS One*. (2021) 16:e0248758. doi: 10.1371/journal.pone.0248758

11. Asiry MA. Dental Students' perceptions of an online learning. *Saudi Dent J*. (2017) 29:167–70. doi: 10.1016/j.sdentj.2017.03.005

12. Linjawi AI, Alfadda LS. Students' perception, attitudes, and readiness toward online learning in dental education in Saudi Arabia: a cohort study. *Adv Med Educ Pract*. (2018) 9:855–63. doi: 10.2147/AMEP.S175395

13. Linjawi AI, Agou S. E-learning readiness among dental students and faculty members pre-Covid-19 pandemic. *J Microsc Ultrastruct*. (2020) 8:168–74. doi: 10.4103/JMAU.JMAU_40_20

14. Al-Harbi KA-S. E-learning in the Saudi tertiary education: potential and challenges. *Appl Comput Info*. (2011) 9:31–46. doi: 10.1016/j.aci.2010.03.002

15. Al-Harbi KRA. Investigating factors influencing the adoption of E-learning: Saudi students' Perspective. University of Leicester (2011).

16. Cidral WA, Oliveira T, Di Felice M, Aparicio M. E-learning success determinants: Brazilian empirical study. *Comput Educ*. (2018) 122:273–90. doi: 10.1016/j.compedu.2017.12.001

17. Sullivan GM, Artino ARJr. Analyzing and interpreting data from Likert-type scales. *J Grad Med Educ*. (2013) 5:541–2. doi: 10.4300/JGME-5-4-18

18. Dhawan S. Online learning: a panacea in the time of Covid-19 crisis. *J Educ Technol Syst*. (2020) 49:5–22. doi: 10.1177/0047239520934018

19. Almahasees Z, Mohsen K, Amin MO. Faculty's and students' perceptions of online learning during Covid-19. *Front Educ*. (2021) 6:638470. doi: 10.3389/feduc.2021.638470

20. Kalghatgi S, Khairnar MR, Dalvi TM, Adaki S, Patil CA, Metha S, et al. Students' preparedness and perception toward online learning in dental education—a cross-sectional study. *Natl J Maxillofac Surg*. (2023) 14:221–5. doi: 10.4103/njms.njms_446_21

21. Azab E, Aboalshamat K. Attitudes, barriers, and experiences regarding E-learning and dental education during Covid-19 pandemic. *Open Dent J*. (2021) 15:464–72. doi: 10.2174/1874210602115010464

22. Taher TMJ, Saadi RB, Oraibi RR, Ghazi HF, Abdul-Rasool S, Tuma F. E-learning satisfaction and barriers in unprepared and resource-limited systems during the covid-19 pandemic. *Cureus*. (2022) 14:e24969. doi: 10.7759/cureus.24969

23. Dacillo MJF, Dizon JKM, Ong EJT, Pingol AML, Cleofas JV. Videoconferencing fatigue and online student engagement among Filipino senior high school students: a mixed methods study. *Front Educ*. (2022) 7:973049. doi: 10.3389/feduc.2022.973049

24. Elshami W, Taha MH, Abdalla ME, Abuzaid M, Saravanan C, Al KS. Factors that affect student engagement in online learning in health professions education. *Nurse Educ Today*. (2022) 110:105261. doi: 10.1016/j.nedt.2021.105261

25. Oducado RMF, Dequilla M, Villaruz JF. Factors predicting videoconferencing fatigue among higher education faculty. *Educ Inf Technol*. (2022) 27:9713–24. doi: 10.1007/s10639-022-11017-4

26. Lepp M, Luik P, Tark TM. How can web lessons be taught to reduce screen fatigue, motivational, and concentration problems in different disciplines? *Front Sociol*. (2022) 7:871770. doi: 10.3389/fsoc.2022.871770

27. Hausfather S. Vygotsky and schooling: creating a social context for learning. *Action Teach Educ*. (1996) 18:1–10. doi: 10.1080/01626620.1996.10462828

28. Ballard J, Butler P. Personalised learning: developing a Vygotskian framework for e-learning. *Int J Technol Knowledge Soc*. (2011) 7:21–36. doi: 10.18848/1832-3669/CGP/v07i02/56198

29. Butnaru GI, Haller AP, Dragolea LL, Anichiti A, Tacu Harsan GD. Students' wellbeing during transition from onsite to online education: are there risks arising from social isolation? *Int J Environ Res Public Health*. (2021) 18:1–23. doi: 10.3390/ijerph18189665

frontiers | Frontiers in Medicine

TYPE Original Research
PUBLISHED 19 July 2024
DOI 10.3389/fmed.2024.1394395

OPEN ACCESS

EDITED BY
Dolores Ortiz-Masià,
University of Valencia, Spain

REVIEWED BY
Yu Chen,
Hangzhou Medical College, China
María Teresa Mendoza,
Shaanxi Normal University, China

*CORRESPONDENCE
Maria Cheraghi
✉ mariacheraghi@gmail.com

RECEIVED 11 March 2024
ACCEPTED 29 May 2024
PUBLISHED 19 July 2024

CITATION
Babadi F, Esfandiari M and Cheraghi M (2024) Evaluating the dentistry program in Iran using the context, input, process, and product (CIPP) model: a comprehensive analysis.
Front. Med. 11:1394395.
doi: 10.3389/fmed.2024.1394395

Evaluating the dentistry program in Iran using the context, input, process, and product (CIPP) model: a comprehensive analysis

Fatemeh Babadi[1], Misagh Esfandiari[1] and Maria Cheraghi[2,3]*

[1]Department of Oral and Maxillofacial Medicine, School of Dentistry, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran, [2]Social Determinants of Health Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran, [3]Department of Public Health, School of Health, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

Introduction: Attaining a commendable level of quality in an educational program is not just important but imperative. Hence, this study was undertaken to assess the quality of the general dentistry program for students in Iran, utilizing the comprehensive Context, Input, Process, and Product (CIPP) evaluation model.

Methods: This cross-sectional study was carried out among dentistry students in the 5th to 13th semesters at Ahvaz Jundishapur University of Medical Sciences in Ahvaz, Iran. Data collection for this research utilized a questionnaire designed in alignment with the CIPP Evaluation Model. The perspectives of students were sought in assessing the four domains of context, input, process, and product. Statistical analysis of the data was conducted using ANOVA and *T*-test methods.

Results: The mean scores of the educational program were as fallow: Content (2.76 ± 0.58), input (2.71 ± 0.65), process (2.51 ± 0.68), and product (3.31 ± 0.68). Overall, the quality of dentistry program was undesirable in all dimensions. Among these dimensions, "product" had the highest mean, while "process" had the lowest mean score.

Conclusion: The results of this study indicate that the general dentistry educational program were Undesirable in all domains. The CIPP evaluation framework assists decision-makers and policymakers in determining the continuation or renewal of a training program by identifying its strengths and weaknesses.

KEYWORDS

curriculum, dentistry, CIPP, Ahvaz, Iran

Introduction

Reviewing the curriculum of universities is a continuous, necessary, and unavoidable phenomenon. Like other scientific fields, dentistry is also influenced by external factors and the development of interdisciplinary advancements (1). Therefore, it is necessary to update its curriculum in line with scientific and environmental changes. Therefore, it is necessary to update the curriculum in line with the scientific advancements and environmental changes. On the other hand, reviewing medical education is inevitable due

to its responsiveness to global trends in healthcare, new technologies, emerging diseases, new patient expectations, the explosion of knowledge, and the increase in information about the human body (2).

Research indicates that dental graduates have reported that their skills and abilities are not up to the desired level (3). For example, the study conducted by Razavi et al. (1) demonstrated that courses in anatomical sciences and oral health and society had the highest alignment with the job requirements of dentists, while courses in parasitology and biostatistics had the lowest alignment.

Evaluation of the dentistry curriculum can be done from various perspectives. One of the important sources in determining the objectives of curriculum programs is the learner, who should have the content of the programs aligned with their needs (4, 5). One of the very important and effective solutions in identifying the quality of clinical education is to examine the opinions of the dentistry student (5).

The CIPP evaluation model (Context, Input, Process, Product), a management-oriented evaluation model, facilitates program evaluation throughout and following implementation across four dimensions: context, input, process, and output (6).

The purpose of evaluating the context is to provide a logical framework for determining educational goals. It also involves analytical efforts to identify relevant elements in the learning environment and to identify problems, needs, and opportunities in a context or educational situation. Input evaluation helps in designing and selecting appropriate methods to achieve the goals (7). Process evaluation is carried out to identify or predict implementation problems in the course of educational activities and to assess the desirability of the process of implementing these activities Product evaluation is conducted to judge the effectiveness of educational activities (8). In fact, the results of the program are compared with the program's goals, and the relationship between expectations and actual results is determined.

A study conducted in 2021 by Rashidi Meybodi et al. (9) Conducted to examine the quality of periodontics educational program in Yazd University of Medical Sciences using the CIPP model. The results of this study indicated that in the periodontics department, input, process and product were undesirable for the students. Based on the above information, it seems that the dental curriculum in Iran should be evaluated and assessed to prevent a decline in global quality standards and irreparable damage to health. So, the aim of this study was to assessment of quality of the general course of dentistry program using the CIPP model as one of the most important and widely used models for evaluation from the view point of the students and then examine the relationship of its dimensions with demographic variables.

Materials and methods

Population and sampling

The present study is a cross-sectional study conducted at the School of Dentistry, Jundishapur University of Medical Sciences in Ahvaz, IRAN in 2023. The target population of this study was all dentistry students in 7th to 13th semesters at Ahvaz Jundishapur University of Medical sciences. Sampling was done by using census sampling method. The inclusion criteria for the study were being a fifth to thirteenth-semester dentistry student, willingness to participate in the study, and completing the informed consent. The exclusion criteria were non-Iranian students who do not have proficiency in the Persian language and who incomplete questionnaire completion.

Measurement

The data collection was after the study approved by the Ethics Committee in Ahvaz Jundishapur University of Medical Sciences (Ethics Code: IR.AJUMS.REC.1402.498).

Standard CIPP evaluation model questionnaire

The questionnaire above has been designed and validated by Mahshid AbdiShahshahani et.al based on the CIPP model for evaluating various educational courses. This questionnaire consisted of two parts. The first part included demographic information such as age, gender, academic semester, grade point average (GPA), and level of interest in the field of study. The second part of the questionnaire consisted of 156 questions in 4 domains: context, input, process, and output. To evaluate the responses, A 5-point Likert scale was used from very high, high, moderate, low, to very low and the range is calculated by (5 - 1). The total scores were calculated and divided by the number of questions. If the final score for each domain was less than 3.7, the status of that domain was considered undesirable; if it was between 3.7 and 4, the status was weak, and if it was between 4 and 5, the status was moderate, and above 5, the status was considered desirable. To assess the validity of the questionnaires, formal and content validity were used, and in terms of the alignment of the questionnaire items with the research topic and objectives, experts confirmed the use of Cronbach's alpha coefficient, with values estimated at (0.98, 0.96, 0.98, 0.98), respectively (6).

Data analysis

Descriptive tables were used to analyze the data, with frequency and percentage indices for qualitative variables, and mean and standard deviation indices for quantitative variables. The distribution of data (normality) was examined using the Kolmogorov-Smirnov test. Independent t-tests and analysis of variance tests were used to examine the mean scores of the questionnaire with demographic variables. Descriptive tables and statistical analysis were performed using SPSS software version. The statistical significance level in this study was set at 0.05.

Results

A total of 245 participants were included in the study. 160 participants were men (65.3%) and 85 participants were

10.3389/fmed.2024.1394395

TABLE 1 Demographic and background characteristics of participants (n = 245).

Variable	Frequency	Percentage	Cumulative frequency	Cumulative frequency percentage
Gender				
Male	160	65.30	160	65.30
Female	85	34.70	245	100
Age				
22–20	71	29.00	71	29.00
22.1–24	73	29.80	144	58.80
24.1–26	50	20.40	197	79.20
26.1<	51	20.80	245	100
Semester				
5	37	15.10	37	15.10
7	53	21.60	90	36.70
9	66	26.90	156	63.60
11	56	22.90	212	86.50
13	33	13.50	245	100
GPA				
12–15.99	89	36.30	245	100
16–17.99	132	53.90	156	63.70
18≤	24	9.80	24	9.80
Level of interest in the academic field of study				
Low	21	8.60	21	8.60
Moderate	76	31.00	97	39.60
High	112	45.70	209	85.30
Very high	36	14.70	245	100

women (34.7%). More than half of the participants were 24 years old or younger (58.8%), while And the other participants, 101 participant (41.2%) were over the 24 years old. The distribution of participants based on their grade point average Students were measured GPA was as follows: only 24 individuals (9.8%) had a GPA of 18 or higher, and nearly half of them (53.3%) had a GPA between 17.9 and 16. Regarding the level of interest in the academic field of study, 148 participants (60%) had a high or very high level of interest, only 21 participants (8.6%) had a low level of interest, and the remaining participants had an average level of interest in their the academic field of study (Table 1).

In Table 2, the Mean (SD) of the four dimensions of CIPP model, including context, input, process, and output, are shown. Overall, the program quality in this study was reported as undesirable in all dimensions. Among these dimensions, "output" had the highest average, while " " had the lowest average.

According to the results of Table 3, a significant difference was observed in the mean score of output dimension among male and female dentistry students participating in the study. Although the output score is undesirable in both age groups, from the perspective of female compared to males, Jundi Shapur Ahvaz University of Medical Sciences has been more successful in achieving the desired effectiveness of the general dentistry education programs (outputs) (P = 0.020).

Based on the results of Table 4, in the context dimension, fifth-semester students had significantly different opinions compared to ninth, eleventh, and thirteenth-semester students, considering the university more successful in the context of the general dentistry education program. Seventh-semester students also

TABLE 2 Mean and SD of course's evaluation dimensions based on CIPP model.

Dimensions	Mean	Standard deviation
Context	2.76	0.58
Input	2.71	0.65
Process	2.51	0.68
Output	3.31	0.68

TABLE 3 Mean and SD of CIPP model's dimensions based on gender difference.

Dimensions	Male	Female	t#	P-value
Context	2.77 ± 0.58	2.75 ± 0.59	0.203	0.840
Input	2.77 ± 0.67	2.59 ± 0.61	1.968	0.050
Process	2.49 ± 0.73	2.54 ± 0.59	−0.651	0.516
Output	3.25 ± 0.66	3.47 ± 0.71	−2.234	0.020*

#Independent sample t-test, *P-value < 0.05.

TABLE 4 Mean and SD of CIPP model's dimensions based on semesters.

Dimensions	5-semester	7-semester	9-semester	11-semester	13-semester	T#	*P*-value
Context	3.05 ± 0.53	2.94 ± 0.52	**2.68 ± 0.56**[be]	**2.53 ± 0.57**[cf]	**2.73 ± 0.63**[d]	6.325	0.001**
Input	2.99 ± 0.64	2.78 ± 0.55	**2.66 ± 0.64** [b]	**2.50 ± 0.70**[cf]	2.72 ± 0.66	3.540	0.008**
Process	2.77 ± 0.61	2.80 ± 0.59	**2.37 ± 0.66**[be]	**2.29 ± 0.73**[cf]	**2.39 ± 0.64**[dg]	6.736	0.001**
Output	3.54 ± 0.65	3.33 ± 0.63	3.34 ± 0.63	**3.22 ± 0.78**[c]	3.23 ± 0.72	1.394	0.237

#One-Way ANOVA ("analysis of variance").
Shows significant difference between measurements ($P < 0.05$). a: significant difference between 5 and 7 Semesters, b: significant difference between 5 and 9 Semesters, c: significant difference between 5 and 11 Semesters, d: significant difference between 5 and 13 Semesters, e: significant difference between 7 and 9 Semesters, f: significant difference between 7 and 11 Semesters. *P*-value for significant results are shown in bold. **P*-value < 0.05, ***P*-value < 0.001.

TABLE 5 Mean and SD of CIPP model's dimensions based on GPA.

Dimensions	≥18	16–17.99	14–15.99	t#	*P*-value
Context	2.91 ± 0.52	2.77 ± 0.58	2.72 ± 0.61	1.001	0.369
Input	2.87 ± 0.68	2.68 ± 0.64	2.69 ± 0.67	0.896	0.409
Process	2.88 ± 0.81	2.49 ± 0.59	2.42 ± 0.75	4.514	0.012*
Output	3.28 ± 0.69	**3.38 ± 0.73**[b]	**3.26 ± 0.61**[a]	0.819	0.442

#One-Way ANOVA ("analysis of variance").
Shows significant difference between measurements ($P < 0.05$). a: significant difference between "≥18" and "14–15.99": significant difference between "≥18" and "16–17.99". *P*-value for significant results are shown in bold. **P*-value < 0.05.

reported higher mean score in the context dimension compared to ninth and eleventh-semester students ($P = 0.05$). In the input dimension, fifth-semester students reported higher mean score compared to ninth and eleventh-semester students.

Based on the results of Table 5 from the perspective of students who had a GPA of 18 and above, the Jundishapur Ahvaz University of Medical Sciences has been more successful in achieving the desirability of the educational programs of the general dental course (output) compared to the other two GPA groups ($P = 0.012$).

Discussion

Based on our research, the present study is the first paper on the educational status of the general dentistry program at Jundishapur Ahvaz University of Medical Sciences. The findings of this research indicate that the general dentistry educational program faced difficulties in achieving its educational objectives in all areas and had undesirable quality in all dimensions during.

According to the findings of the present study, the quality of the educational program was undesirable in the context dimension. More than 50% of the students mentioned the student-to-teacher ratio, insufficient clinical departments and operating rooms, lack of student rest areas, inadequate computer systems, lack of appropriate nutrition facilities in the faculty, inadequate financial budget, and unsuitable educational materials as reasons for the poor quality of the educational context. The results of this study were inconsistent with the findings of Makarem et al. (10) and Rashidi et al. (9). In the study by Rashidi et al. (9), the quality of educational program was examined in periodontics and oral health departments at Yazd University of Medical Sciences, It was demonstrated in the study that the context quality was relatively desirable in the periodontics and oral health departments. Furthermore, according to the findings of the present study, in the research conducted by Jafari et al. (11) at the School of Dentistry in Tehran University of Medical Sciences, students expressed dissatisfaction with the lack of sufficient educational equipment, inadequate human resources, and insufficient provision of adequate spaces.

One possible reason for this difference could be that most students of Ahvaz University of Medical Sciences have achieved higher rankings in the national entrance exam compared to Yazd University of Medical Sciences, and therefore have higher expectations from the accepted university. Another important reason is the relatively limited physical space of the dental school, which is evident in the related responses regarding the lack of suitable practice rooms, insufficient space for the school's cafeteria, insufficient space for clinical departments, and lack of dedicated spaces for students. It seems that allocating more space to the dental school is necessary to address this issue. It is strongly recommended to organize courses for utilizing educational videos as another solution to enhance the quality of educational program context.

Based on the findings of the present study, the input was considered undesirable. The analysis of the results showed that, the content and educational objectives, educational facilities, offered courses, sequence and logical connection between the courses, computer and library facilities were all considered undesirable. One of the most important problems in the field of internal data was that 60% of the students identified problems in the lack of compatibility between the number of students and the "educational and recreational facilities" and the "sports and recreational facilities". It seems better to reconsider the increase in the capacity of dental fields or allocate more financial resources to provide educational, cultural, and welfare facilities. In the study by Tabari et al. (12), the analysis of the results showed that, the content and educational objectives, educational facilities, the number of attendees (patients), the number of professors, the skills of professors, and the supervision of students' performance were desirable. In the study by Makarem et al. (10), the quality of

intraoperative education programs in the periodontics department and in the social oral health and dentistry department was relatively satisfactory, which contradicted the present study. It is possible that due to the presentation of a high volume of content in the curriculum, theory-based education may not be consistent with practical needs, and this lack of coherence may be the reason. On the other hand, differences in the treatment protocols used by professors in different groups, as well as the lack of alignment of some treatment with the protocols provided in the references, can be reasons for students' acquired perspectives. Despite these potential shortcomings, further investigation is needed to find possible solutions and address them.

Based on the findings of the present study, the process dimension were considered undesirable. The evaluation of the process is carried out in order to identify or predict executive problems in the course of educational activities and the desirability of the implementation process of these activities. In the present study, the lack of importance given to student opinions in planning, the lack of welfare facilities in the department, and the mismatch between the number of students and the physical space were among the most important areas of low-quality processes. One of the factors evaluated in the scope of the process was the use of innovative teaching methods for better learning of learners and the use of new clinical training facilities to improve the educational level, which according to 56% of students, innovative teaching methods were not used, and according to 58% of students, new training facilities were not utilized. In contrast to the present study, Jafari et al. (11) reported relatively desirable quality scores for educational program processes. Similarly, in Rashidi Meybodi et al.'s study (9), in the oral health group of Yazd University of Medical Sciences, all four areas were of desirable quality.

From the perspective of students, the weaknesses that existed in the product were: the lack of teamwork among students and professors, inappropriate feedback from university officials in clinical education, inappropriate customer satisfaction and orientation, and inappropriate cost reduction and efficiency. Alongside the present study, the quality of the education program at Mashhad University of Medical Sciences was also undesirable (10). A qualitative study by Kham Verdi et al. (13) at Hamadan University of Medical Sciences on graduates of the general dental program showed that the achievement of educational goals in theoretical education for the restorative group was desirable, which contradicted the results of the present study. In the research by AliMohammadi et al.(14) Conducted at Rafsanjan Medical School, the product was relatively evaluated as desirable, which was not consistent with the results of the present study. It seems necessary to adopt strategies to improve the educational experience of students and ensure appropriate and desirable interaction between officials and students.

Based on the findings of the present study, from the perspective of female students compared to males, Jundishapur Ahvaz University of Medical Sciences has been more successful in achieving the desirability of the product of general dentistry education program. This study is in contrast to the study by Rashidi Meybodi et al. (15), in which no significant difference was observed between the opinions of female and male students in the four domains of CIPP in the periodontics course. In the study by Zamanzad et al. (16), it was also reported that gender did not play a significant role in the satisfaction with the quality of clinical course education at Shahrekord University of Medical Sciences. It seems that discovering the possible causes of these differences requires further investigation, but it is possible that these differences are due to societal expectations and culture, which impose greater stress on males to achieving professional success{Rafatjah, 2012 #163}. Therefore, these stress may be the reasons for these differences.

Furthermore, the present study has shown that eleventh-semester students have the least satisfaction in all dimensions except for the process compared to students 1 year below themselves. The findings of the present study were consistent with Rashidi et al. (9) Study, as in that study, both groups of periodontics and oral health departments reported that eleventh-semester students have the least satisfaction. It seems that the increase in awareness and insight of students in higher semester, as well as their interest in continuous learning and their stress for entering the job market, has created a general dissatisfaction among this group of students; while the level of satisfaction may increase slightly in the thirteenth semester due to the acquisition of more skills and experience.

According to the findings of the present study, there was a significant difference in the output dimension of the general dental education program among students with different GPAs. In other words, from the perspective of students who had a GPA of 18 and above, Jundishapur Ahvaz University of Medical Sciences has been more successful in achieving the desirability output of the educational program for general dental education. Very few studies have considered the important variable of students' GPA in evaluating their quality of the educational program. Based on the research team's searches, only in the study of Mirzaei Alavijeh et al{Mirzaei-Alavijeh, 2021 #165}, had examined this variable, and showed a relationship between high GPA and better evaluation of the educational program process. It seems that this relationship indicates the importance of appropriate assessment methods in training and the significance of considering students' opinions in implementing the desired educational programs.

Conclusion

Despite the 2012 updates aimed at tackling issues like overcrowding and limited elective courses in the dental curriculum, student perception suggests that the desired quality remains elusive. The latest revisions appear to have fallen short in boosting student satisfaction. The presence of dynamic young faculty members and adequate resources lays the foundation for progress. Acknowledging these findings and engaging stakeholders, particularly students, can amplify effectiveness and drive educational program enhancements for overall improvement.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Ethics Committee in Ahvaz Jundishapur University of Medical Sciences (Ethics Code: IR.AJUMS.REC.1402.498). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

FB: Supervision, Writing – review and editing. ME: Project administration, Writing – original draft. MC: Conceptualization, Formal analysis, Supervision, Writing – review and editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This research was funded by the Ahvaz Jundishapur University of Medical Sciences.

Acknowledgments

We are grateful to the participants, field workers, and co-researchers involved in this study. This work was a part of dissertation of ME (U-02320) at the School of Dentistry.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Rezaei Z, Ramazanzade K, Abbaszadeh H. The degree of compliance of the content of the general dentistry curriculum with job needs from the perspective of dentists in Birjand. *Iran J Med Educ.* (2021) 21:68–81.

2. Ahangari Z, Rahmani M, Sohrabi Z, Kharazifard M. Dental Curriculum According to Views of the Graduates of Dental Schools of the Country During the Last 5 Years. *Shahid Beheshti Univ Dental J.* (2010) 28:80–87.

3. Nejad Shamsi P, Zaker-Jafari H, Basirat M, Zaker-Jafari A. Self-assessment of senior dental students about acquired skills based on the educational program. *Res Med Educ.* (2017) 9:78–73. doi: 10.29252/rme.9.3.79

4. Khoshrang H, Salari A, Dadgaran I, Moaddab F, Rouh-Balasii L, Pourkazemi I. Quality of education provided at the clinical skills lab from medical students' viewpoints in Guilan University of Medical Sciences. *Res Med Educ.* (2016) 8:77–83. doi: 10.18869/acadpub.rme.8.2.77

5. Babaee N, Jahanian I, Bijani A, Ardebili Haghighi MR. Viewpoints of dental students about practical value of educational contents in oral medicine department. *Med Educ J.* (2014) 2:35–40.

6. AbdiShahshahani M, Ehsanpour S, Yamani N, Kohan S, Hamidfar B. The evaluation of reproductive health PhD program in Iran: a CIPP model approach. *Proc Soc Behav Sci.* (2015) 197:88–97. doi: 10.1016/j.sbspro.2015.07.059

7. Rachmaniar R, Yahya M, Lamada M. Evaluation of learning through work practices industry program at University with the CIPP model approach. *Int J Environ Eng Educ.* (2021) 3:59–68. doi: 10.55151/ijeedu.v3i2.55

8. Riyad MK, Wang Y, Pakarinen J. Measuring the professionality of school teachers' performance: the context, input, process, and product (CIPP) model'. *Int J Innov Creativ Change.* (2020) 12:386–99.

9. Rashidi Maybodi F, Hosseini-Yekani A, Golshahi N. Assessment of educational status of periodontics and oral health and community dentistry departments in Yazd dental school using CIPP model in 2018. *JSSU.* (2021) 29:4046–56.

10. Makarem A, Movahed T, Sarabadani J, Shakeri MT, Asadian Lalimi T, Eslami N. Evaluation of educational status of oral health and community dentistry department at Mashhad Dental School using CIPP evaluation model in 2013. *J Mashhad Dent Sch.* (2014) 38:347–62.

11. Jafari A, Khami M, Yazdani R, Mohamadi M. Presenting the course of community dentistry as problem based learning workshop and comparing it to learning through lecture. *Iran J Med Educ.* (2010) 9:216–24.

12. Tabari M, Nourali Z, Khafri S, Gharekhani S, Jahanian I. Evaluation of educational programs of pediatrics, orthodontics and restorative departments of babol dental school from the perspective of the students based on the CIPP model. *Caspian J Dent Res.* (2016) 5:8–16.

13. Khamverdi Z, Kasraee S, Rostamzadeh T, Yekta H. Educational objectives achieved by department of operative dentistry: viewpoints of general dentists graduated from Hamedan dental school (2004-2009). *Iran J Med Educ.* (2012) 12:387–95.

14. Alimohammadi T, Rezaeian M, Bakhshi H, VaziriNejad R. The evaluation of the Medical School Faculty of Rafsanjan University of Medical Sciences based on the CIPP model in 2010. *J Rafsanjan Univ Med Sci.* (2013) 12:205–18.

15. Rashidi Maybodi F, Hosseini-Yekani A, Golshahi N. Assessment of educational status of periodontics and oral health and community dentistry departments in yazd dental school using CIPP model in 2018. *J Shahid Sadoughi Univ Med Sci.* (2021) 29:4046–56. doi: 10.18502/ssu.v29i8.7665

16. Zamanzad B, Moezi M, Shirzad H. *Rate of Satisfaction and Evaluation of Medical Students (Interns and Externs) from the Quality of Clinical Education in the Shahre-Kord University of Medical Sciences-2005.* (2007) 9:13–20.

Frontiers in Medicine

Translating medical research and innovation into improved patient care

A multidisciplinary journal which advances our medical knowledge. It supports the translation of scientific advances into new therapies and diagnostic tools that will improve patient care.

Discover the latest Research Topics

See more →

Frontiers

Avenue du Tribunal-Fédéral 34
1005 Lausanne, Switzerland
frontiersin.org

Contact us

+41 (0)21 510 17 00
frontiersin.org/about/contact