

Artificial Intelligence: Friend or Foe in the Assessment of Dental Students?

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Abstract:

Objectives: Incorporating artificial intelligence (AI) in assessing dental students' knowledge and skills is in its infancy, despite AI being well established as an aid to aspects of clinical diagnosis and education. This study aimed to investigate whether dental educators perceived AI as beneficial in assessing students.

Methods: This was a mixed methods study where quantitative and qualitative data were generated through a live online polling system, Vevox™. Quantitative data were collected, findings of which were immediately shared with dental educators attending the workshop at a European wide dental educators' conference. Qualitative data were collected at the workshop via word clouds as part of the online questions, and by asking participants to write down their views, opinions and reflections. Analysis was descriptive and thematic respectively.

Results: 51 conference delegates attended the workshop. 14 questions had a response rate of over 69%, two questions had response rates of 53% and 57% respectively. 65% (n=33) of participants considered that their dental school provided support and training in using AI. Dental educators were uncertain whether assessments of dental students generated by AI were effective in testing students' knowledge/competence, 47% (n=18). One third of the participants were sure that AI generated assessments were more effective (34%; n=13). Less than half the participants were confident in using AI in assessing dental students (2.24/4; [SD 1.0588]). Thematic analysis revealed key themes: training, effectiveness of AI assessment, current use of AI, concerns, confidence, and advantages/disadvantages.

Conclusions: This study illustrated the diversity in knowledge, confidence and application of AI in the assessment of dental students, and the need for universities and dental schools to invest time and expertise in supporting dental educators in this important area.

Clinical Significance: The education and assessment of dental students should ensure that caring, knowledgeable and skilful practitioners are entrusted with patients care. The use of Artificial Intelligence to support or replace previous assessment techniques need to be understood by dental educators, to ensure that the assessments are robust, validated and workable.

Key Words: Artificial Intelligence; assessing dental students; dental teachers opinions; knowledge of AI, confidence with AI.

Introduction:

Artificial Intelligence (AI) is revolutionising many fields, and its adoption is rapidly evolving. The use of AI in education, including dental education, has also rapidly developed in recent years, although a degree of caution regarding its applicability in education has been reported [1]. The use of AI in educating medical students' needs to develop to satisfy the demands of both the current and future healthcare workforce and increasing expectations from patients [2]. In the assessment of healthcare students, AI has been reported to, "mark a significant shift, offering both stimulating opportunities and notable challenges for authentic assessment practices" [3]. In particular, the integration of AI in dental student assessments has been reported to offer numerous benefits, enhancing both the learning experience and the evaluation process [4].

Mirchi et al. [5] used AI for simulation-based training of medical students and created a "Virtual Operative Assistant", to provide automatic feedback to students based on measurements of their performance. From a formative educational paradigm, including Behaviourism, Information Processing and Cognitive Psychology, Individual Constructivism and Social Constructivism & Situated Learning. Mirchi et al. (2020) [5], also reported that integrated virtual reality and AI could classify students according to proficiency performance benchmarks. Appropriate feedback can be provided to meaningfully facilitate ongoing student learning [6]. AI has also been used to create questions for online student assessment [7].

Intelligent tutoring systems can monitor students' progress, identify knowledge gaps, and provide targeted recommendations for further study. This adaptive learning approach ensures that students receive the support they need to succeed [8]. In addition, AI can facilitate peer assessment by matching students with similar skill levels, promoting collaborative learning and critical thinking in healthcare education [9].

The use of AI in dental education has been well documented, however, the use of AI in the assessment of dental students is less clear cut as the diversity of tools for assessing knowledge and skills increases [10].

AI technologies, such as machine learning and natural language processing, are being increasingly utilized in dental education to improve the efficiency and efficacy of student assessments [8]. One significant application is the use of AI for automatic grading. AI systems can evaluate written assignments, multiple-choice questions, and even practical examinations with high precision. This not only reduces the workload for educators but also ensures consistent and objective grading [11].

The aim of this study was to investigate dental educators' knowledge, application, confidence and perceptions of the use of AI in the assessment of dental students.

Materials & Methods:

This was a mixed methods study where both quantitative and qualitative data were generated through a live polling system, Vevox™ with subsequent participant group discussions. The qualitative data were further supplemented with handwritten responses from the participants, following some additional questions posed by the four authors acting as facilitators. Participants responded to the Vevox™ based questions accessed via a QR code using their mobile phones. Fifty-one volunteer participants representing dental educators across Europe and the rest of the world attended the workshop. A total of 16 questions were divided into four themes: i) Dental educators' knowledge of AI in student assessment; ii) The impact of AI on the design and delivery of student assessment; iii) Educators' concerns with AI and iv) The future of AI in student assessment. No differentiation was made in the questions or respondents between undergraduate and postgraduate students. The Vevox™ based responses were shared in real time with the participants and the additional handwritten qualitative responses were collected at the end of the session. Relevant discussions amongst the participants after each Vevox™ question were noted by the four facilitators and added to the qualitative data collected. Quantitative data were analysed descriptively, and qualitative data were analysed thematically.

Quantitative data were stored on the Vevox™ app and transferred to an Excel spreadsheet. They were analysed using descriptive statistics and means and standard deviations were generated. Qualitative data were stored on a Word document, transferred to a "Framework analysis" and analysed thematically (Hackett & Strickland, 2019) [12].

Ethics approval was granted by the University College London Research Ethics Committee. (Ethics ID: 6552.01 4).

Results:

Quantitative data:

Fifty-one participants took part in the workshop, which ran as part of the Association of Dental Education in Europe (ADEE) annual conference. Although the number of participants in the room remained static at 51, not all participants responded to all the questions. Fourteen of the 16 questions had a response rate of over 69%, the remaining two questions had response rates of 53% and 57% respectively. The majority of participants were aged between 28 and 59 years of age (71%; n=25) and two thirds of participants taught undergraduate dental students (67%; n=24) (See Figure 1).

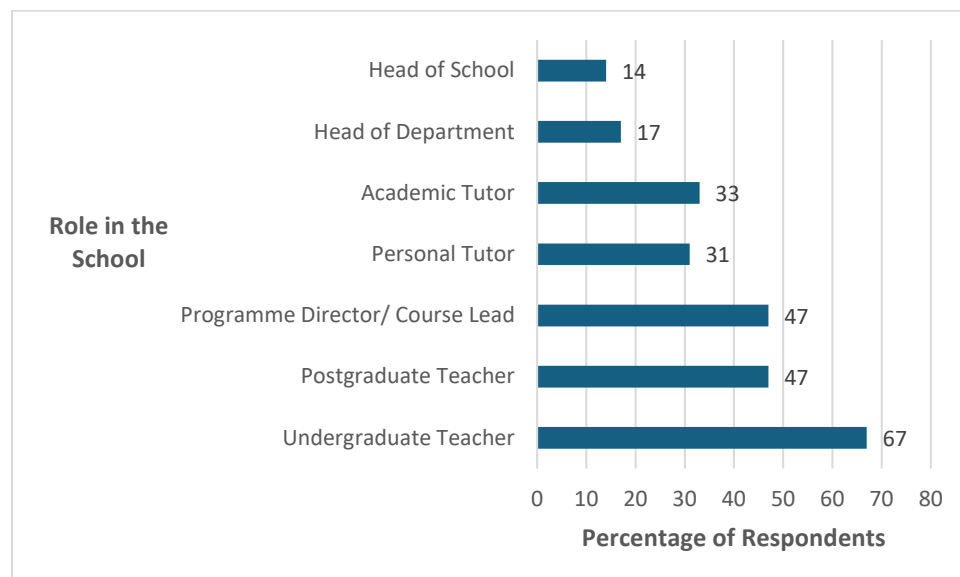


Figure 1. The Roles of Participants in Dental Schools (The percentages displayed reflect the number that responded to the question).

The most popular responses to the question about the AI technologies currently used in the assessment of dental students were ChatGPT™, CoPilot™, Moodle™ and WiseFlow™. Less popular technologies included Wooclap™, Liftupp™ and Blackboard™.

Two thirds of the represented dental schools reported the provision of support and training in AI for their dental educators (65%; n=33). Support and training particularly in CoPilot™, ChatGPT™ and Moodle™ were most commonly requested by the participants. However, a small number of participants commented that they were either not yet ready to use AI based technologies or that they were not aware of what technologies were available to use. Almost three-quarters of participants (71%; n=27) reported that they did not currently use AI to assess students. Those participants who did use AI to assess their students, used a variety of technologies to generate a range of assessment options (Figure 2).

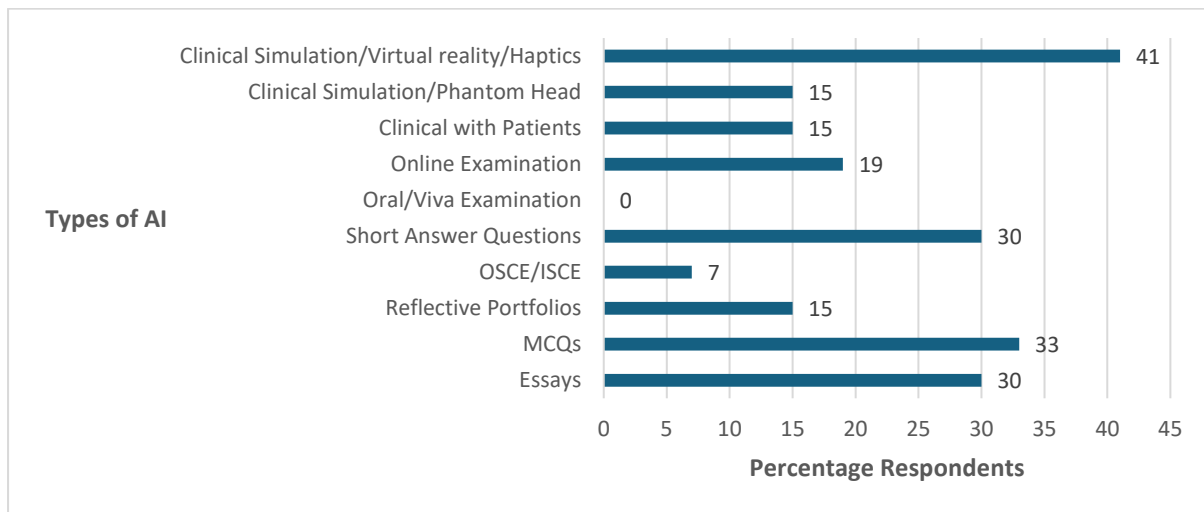


Figure 2. Types of AI Currently Used by Participants

When asked if dental educators thought that the methods of assessment generated by AI were more or less effective in testing students' knowledge or competence, 47% (n=18), were unsure, with one third being sure that those assessments were more effective (34%; n=13). However, when asked if dental educators thought students were using AI to answer assessments, 43% (n=17) reported they were but with permission. 38% (n=15) reported their students were using AI to answer assessments but without permission. 56% (n=22) of the participants expressed concern about their students using AI for assessments. When asked if participants were confident in using AI in assessing dental students, the mean score amongst 41 teachers who answered this question, was 2.24/5; (SD 1.0588) indicating less than half were fully confident.

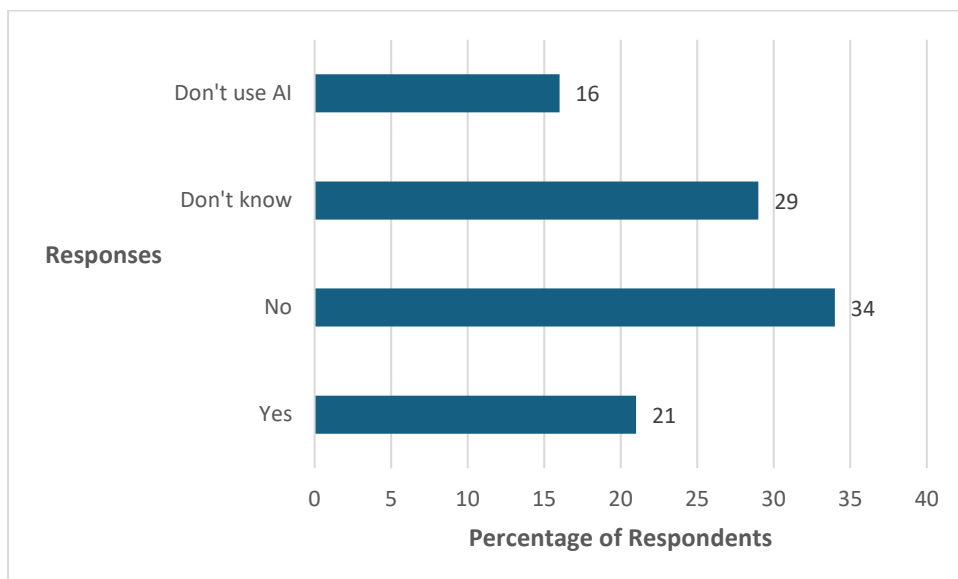


Figure 3. Has the use of AI influenced students' involvement in designing assessments?

For the question relating to co-creation, most participants either did not know or were clear that students were not involved in developing their own assessments, (63%; n=24) (See Fig. 3). Only one in five participants indicated that students were involved in co-creation.

Participants reported that the advantages of using AI for student assessment were time saving/speed and accuracy. Whereas the disadvantages included an overwhelming number of participants indicating potential cheating as the main disadvantage.

Qualitative data:

Qualitative data were collected in two formats: a) “word clouds” in response to Vevox™ questions and b) free text responses to some Vevox™ questions. A thematic approach to analysis was adopted (See Table 1). Examples of written feedback within each theme are illustrated below.

Theme	Sub-theme
1. Training	University Online Workshops
2. Effectiveness of AI assessment	Lack of experience Human input Type of assessment
3. Current use of AI	Students Teachers
4. Concerns	Students Teachers: Concerned Not concerned
5. Confidence	Knowledge Training
6. Advantages/Disadvantages	Various

Table 1. Thematic analysis of qualitative data

Theme 1: Training:

Most participants reported that they had received and continued to receive training and support with AI from their university/dental school. A variety of methods was adopted to support and train dental educators including workshops, online courses and lectures. A range in the frequency and quality of training was reported, with online courses accessible both continuously and occasionally throughout the year.

"There is an outline training available all the time"

"Yes, workshops and discussions on use of AI but they are not particularly helpful"

"My university provides courses in AI for use as a teacher, but I am unsure if they provide courses in AI for student assessment"

"Support provided by my university. They organise workshops. This support is an introduction, but more tech support is needed"

A minority of participants reported no/limited support from their university/dental school:

"No specific support on using specific AI tools such as Chat GPT (e.g. formulating prompts) and detecting AI involvement in submitted summative assessments"

"No support/or training (related to dentistry during assessment)"

Theme 2: Effectiveness of AI assessments:

There was a general feeling of uncertainty when participants considered the effectiveness of AI when used in conjunction with assessing dental students. The uncertainty stemmed from a lack of experience of using AI, the need for a human touch and the topic being assessed.

"Not sure. Need to see some more data and longitudinal data on outcomes"

"Don't know enough about AI to decide properly"

"Equally effective because there will be my supervision in the decision of marking the assessment"

"Of course, you need a human/professional to watch critically at the output"

"I think it would be more effective because assessment generated by AI may have more specificity or may be more validated and checking their quality and reliability"

"It is depending on what we want to assess. If we want to assess skills like professionalism, ethics, communication, reflection and critical thinking skills I think AI is less effective but as assessment of more theoretic topics AI perhaps is more effective"

Some participants clearly had some good experiences with using AI in developing student assessments and were very positive about the prospects of using AI in this way.

“Methods of assessment generated by AI are more effective because students are then brought to the next level in terms of critical evaluation and analysis. Hence assessments are more difficult & more discriminative”

“More effective, AI is objective, not biased, has access to larger databases than humans, it [is] based on experience of thousands of humans who feed the internet, while the single human being is somewhat limited in creation of assessment, often having valued for a long time, does not want to introduce novelties at work but to [remain] continuous as it used to be for years”.

Theme 3: Use of AI:

Participants presented a mixed picture when asked about the current use of AI in student assessment. Many acknowledged that students were using AI to help with their assessments, some with permission of the university and some without.

“I am sure they do. We can’t fight AI, we just have to embrace it”

“Yes, but without permission. Due to unclear university policy on use of AI for assessment”

Some participants felt that AI was being used by students who did not fully understand the benefits of using AI.

“For those who use it I am not sure they quite know how to use it yet”

“They are using AI, but they use it for the full answer, not just like a guidance through their learning process. However, if they understand the real use of AI [it] could be more effective”

Several participants stated that students either have or do not have permission to use AI in some of their assessments and therefore the criticism of examination malpractice involving AI could not be made. Other participants reluctantly agreed that students did use AI in their assessments, and its use was considered inevitable.

“It is difficult to say precisely because the amount of use of AI differs a lot from student to student. But the university has set the rule that AI is permitted at all times if the teachers have said it is okay.....”

"Yes [students are using AI] but without permission. Due to unclear university policy on use of AI for assessment"

"The students use AI as they are encouraged to do so"

"As many of [the] staff and students use ChatGPT I have to assume it's used in answering essays but it is not allowed as it is seen to be cheating"

Theme 4: Concerns:

There were contrasting concerns expressed by the participants about using AI in student assessment. Some unease was voiced about the type of assessment that had been set and whether this had an impact on the validity of including AI in assessments. Participants stated that AI had a negative effect on student learning and their application of knowledge to the clinical environment.

"We still have traditional assessments (e.g. short answer questions) that can be easily answered by AI. Hence, I am concerned about students using AI to complete this type of assessment"

"Concerns over level of understanding and depth of their knowledge. What working knowledge will they hold e.g. for clinics"

"Some of the answers can be wrong because of the material in, for example ChatGPT can be wrong. It is time consuming to assess those answers and check references"

"Extremely concerned around ethical usage; how they [students] are using and how to monitor usage, sustainability issue (environmental and technical)"

"I am not concerned about the students using AI, I think that we just have to adapt and develop our assessment methods"

Theme 5: Confidence:

Most participants reported a lack of confidence when it came to using AI, particularly in the assessment of dental students. Some participants linked their lack of confidence with a lack of knowledge of AI. Quantitative data analysis revealed a mean value of confidence of 2.24 (on a scale of 0-4, where 0=not at all confident and 4= very confident). This was reinforced by the qualitative findings.

"Not confident, because I don't have enough time to learn adequately the wide range of AI tools available which might help in student assessment. But for wider technologies I am very confident in using simulations and haptic devices to assess some student clinical skills"

"Because I do not know enough about the possibilities and the Pros/Cons, how it works so [I have] very little confidence in using AI"

I am confident but not super confident as I do not know of best practice in using AI for student assessment. I feel it is very much a work in progress as AI is progressing so fast. i.e. what is OK today may not be fine in 6-months' time"

"Lack of clear guidance by the school/university on what is permissible"

There were also some indications that the participants' lack of confidence was linked to a lack of training and the limits of technology.

"I think I could do it with more training"

"I am confident in using AI in assessment, however there are some technical settings that must be tested in order to check that the assessment is well designed"

"Not sure- there are always concerns with new technology, but we have to deal with it; we will see".

Theme 6: Advantages/Disadvantages:

The main advantages of using AI to help with assessments were the saving of time and greater efficiencies due to eliminating human errors.

"Time saving because AI does the work and not humans/teachers"

"AI has the potential to make the assessment more time efficient"

"Less of faculty manpower/resources needed when AI used"

The main disadvantages included concerns with how contemporary the information on AI is, ethical considerations, and the impact on teachers.

"Quality control issues and errors that aren't obvious. Can one fully trust AI not to make mistakes that we find difficult to spot/identify"

“I don’t think the majority of dental educators have the time to learn the wide range of AI tools which could be used. AI could be used to create model answers for exam questions.....”

“Not enough control is reported on the cheating possibilities of creative AI. And there is the risk for data protection, both about students and about patients”

“Encourages staff laziness”

“Accountability- will the teacher be held accountable? Authenticity- does it reflect the current knowledge? Accuracy -fast checking”

Discussion:

AI is used by some teachers and students both to design and complete dental assessments, but there are concerns about its usage. AI has already been demonstrated to be a reliable tool in improving patient care via more accurate diagnoses [13], time efficiencies, and economies of practice for clinicians [14]. However, the use of AI in assessing dental students is far more challenging for dental teachers, who are still trying to come to terms with and decide how best they can use AI to support and assess their students.

As technology continues to evolve, new uses of AI will undoubtedly appear. The use of problem-based learning (PBL), which by definition involves the students [15], is considered to be a good model for dental and medical education. Assessment of learning outcomes, student self-efficacy, group dynamics, and stakeholder feedback are required to measure the effects of AI in the PBL curriculum, and in particular the use of ChatGPT as observed by Divito et al. [16]. Similarly, one observation made by the participants in the current study is the requirement to continuously update their knowledge and skills as new software applications become available. The use of AI in dental student assessments is becoming well established and dental educators must learn to both adapt and adopt. However, in the current study dental educators also expressed a strong desire to maintain traditional assessment techniques for students whilst adopting the new AI based assessments, as similarly reported by Claman & Sezgin [17].

Although it is time consuming and expensive, universities and dental schools should continuously update their teachers on the ongoing developments in AI [8]. Further to this, participants in this current study were clear that although their universities and dental schools were providing some guidance, it needs to be contemporary, affordable and accessible.

This study demonstrates the need for dental education providers to recognise the impact of rapid technological advances on dental education, as reported by Ali et al. [18]. Effective strategies are required to mitigate against the inappropriate use of technology to ensure that students and faculty can benefit from new technologies [19]. In agreement with Bitar &

Davidovich [20], this is not the first time that education providers are confronted by the challenges posed by innovative technologies. All the dental educators participating in this study will have witnessed the impact of the ongoing internet revolution in education. Access to information has been transformed by powerful search engines such as Google, web-based applications such as YouTube and the use of digital flashcards [18].

Participants in this study referred to AI-powered simulation tools transforming the assessment of dental students' clinical skills. Also, virtual patient simulations allow students to interact with realistic patient scenarios, enhancing their diagnostic and treatment planning abilities. These simulations can be tailored to individual learning needs, offering a personalised learning experience as endorsed by Fang et al. (2024) [21].

In the current study the participants expressed concerns about how the rapid advancement of Generative AI is disrupting traditional assessment methods including essays, MCQs and short answer questions. The use of essays as a mode of assessment has been used in education for generations. However, AI tools like ChatGPT and CoPilot are now capable of generating text, raising concerns about plagiarism, the originality of thinking and the integrity of academic work. Students were also reported to often use grammar correction tools and style guides, which have become acceptable with some dental educators. However, the use of AI for text generation requires careful consideration to avoid potential assessment malpractices such as plagiarism. Students need to be reminded to credit all sources appropriately, including AI-generated texts, and to understand the legal implications of using such technology as reported by Thurzo et al. [8].

Adopting an online polling system for data collection has many advantages, such as the immediacy of the results which are visible to all participants, generating meaningful discussion. However, it is impossible to ensure that all the participants will respond to all the questions posed within the allocated time. This study did not enquire about the age and specific demographic data such as years of experience as dental educators, which could have been a confounding factor possibly influencing the results.

AI is a rapidly growing technological advancement which is impacting education at all levels and across all fields. Although the trend for its use is clearly upward, in dental education it is still not as prevalent or prolific, probably due to a lack of knowledge on the part of the users, agreeing with Prendes Espinosa & Cartagena, [22].

Conclusions:

This study has illustrated the diversity in knowledge, confidence and application of AI in the assessment of dental students and the need for universities and dental schools to invest time and expertise in supporting dental educators. The ultimate challenge for AI is to more effectively facilitate learning than traditional methods to produce more skilled and knowledgeable dentists who can operate safely and effectively for the benefit of the Oral Healthcare of patients in an ever-changing environment.

The benefits of AI in enhancing the quality and efficacy of dental education are undeniable. As AI technologies continue to evolve, their applications in dental student assessment are likely to expand, offering new opportunities for innovation in dental education. However, the integration of AI in dental education is not without its challenges. Concerns about data privacy, the need for a substantial initial investment in both equipment and software and the potential for over-reliance on technology must be addressed.

References:

1. Selwyn, N. 2022. The future of AI and education: Some cautionary notes. *Euro J Educ. Research, Develop. Policy* Vol 57 (4):620-631
2. Masters, K. 2019. Artificial intelligence in medical education. *Medical Teacher*; Vol 41, (9): 976-980
3. Fatima, Sheikh, Osama. 2024. Authentic assessment in medical education: exploring AI integration and student-as-partners collaboration. *Postgrad Med J. Jul* Vol 23:qgae088
4. Ali, Barhom, Tamimi, Duggal. 2024. ChatGPT-A double-edged sword for healthcare education? Implications for assessments of dental students. *Eur J Dent Educ. Feb*; Vol 28(1):206-211
5. Mirchi; Bissonnette; Yilmaz; Ledwos; Winkler-Schwartz; Del Maestro. 2020. The Virtual Operative Assistant: An explainable artificial intelligence tool for simulation-based training in surgery and medicine. *PLoS ONE* 2020, 15, e0229596.
6. Leung, Fine, Blizard, Tonni, Louca. 2021. Teacher feedback and student learning: A quantitative study. *EJDE*, Vol 25, (3):600-606
7. Janpla; Piriya-surawong. 2020. The Development of an Intelligent Multilevel Item Bank Model for the National Evaluation of Undergraduates. *Univers. J. Educ. Res.* 2020, 8, 4163–4172.
8. Thurzo, Strunga, Urban, Surovkova, Afrashtehfar. 2023. Impact of Artificial Intelligence on Dental Education: A Review and Guide for Curriculum Update. *Educ. Sci.* 2023, Vol 13(2), 150; <https://doi.org/10.3390/educsci13020150>

9. Fatima, Sheikh, Osama. 2024. Authentic assessment in medical education: exploring AI integration and student-as-partners collaboration. *Postgrad. Med. J*, Vol 100, (1190):959–967
10. Louca C, Fine P, Tonni I, Leung A. 2024. Reviewing Assessment Strategies in European Dental Schools. *Journal of Dentistry*. 2024:105091.
11. Bayrakdar, Orhan, Jagtap. 2024. Artificial Intelligence in Dental Education. In: Orhan, K., Jagtap, R. (eds) *Artificial Intelligence in Dentistry*. Springer, Cham.
https://doi.org/10.1007/978-3-031-43827-1_13
12. Hacket & Strickland. 2019. Using the framework approach to analyse qualitative data: a worked example. *Nurse Res*. Sep 21; Vol 26(2):8-13
13. Qutieshat , Al Rusheidi , Al Ghammari , Alarabi , Salem, Zelihic. 2024. Comparative analysis of diagnostic accuracy in endodontic assessments: dental students vs. artificial intelligence. *Diagnosis*, Vol 11(3)
14. Ahmed, Abbasi, Zuberi, Qamar, Bin Halim, Maqsood, Alam. 2021. Artificial Intelligence Techniques: Analysis, Application, and Outcome in Dentistry-A Systematic Review. *Biomed Res Int*. Jun 22:2021:9751564
15. Shaju Jacob P. 2011. Problem based learning in dental education. *Journal of Education and Ethics in Dentistry* January-June 2011 Vol. 1(1):7-11
16. Divito, Katchikian, Gruenwald, Burgoon. 2023. The tools of the future are the challenges of today: The use of ChatGPT in problem-based learning medical education. *Medical Teacher* Vol 46 (3):
17. Claman & Sezgin. 2024. Artificial Intelligence in Dental Education: Opportunities and Challenges of Large Language Models and Multimodal Foundation Models. *J. Med. Internet Research Med Educ*. 2024;10:e52346;
18. Ali K, Alhaija, Raja M, et al. Blended learning in undergraduate dental education: a global pilot study. *Med Educ Online*. 2023; 28(1):2171700.
19. Johnson, Jacovina, Russell, Soto. 2016. Challenges and solutions when using technologies in the classroom. In S. A. Crossley & D. S. McNamara (Eds.) *Adaptive Educational Technologies for Literacy Instruction*. Taylor & Francis, Routledge:
20. Bitar & Davidovich. 2024. Transforming Pedagogy: The Digital Revolution in Higher Education. *Educ. Sci*. 2024, 14(8), 811; <https://doi.org/10.3390/educsci14080811>
21. NY. Fang, Reynaldi, Araminta, Kamal, Saini, Afshari, Tan, Yuan, Qomariyah, Sukotjo. Artificial Intelligence (AI)-driven dental education: Exploring the role of chatbots in a clinical learning environment. *The Journal of Prosthetic Dentistry*. Available online 20 April 2024.
22. Prendes Espinosa; Cerdán Cartagena. 2021. Advanced technologies to meet the challenge of educational innovation RIED. *Ibero-American Journal of Distance Education*, Vol. 24 (1): 33-53

Funding Source Declaration: There was no funding application for this manuscript/study. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Interest: There's no financial/personal interest or belief that could affect the authors objectivity. All authors have been asked about financial/personal interests and all have denied any

Author Agreement: We certify that all authors have seen and approved the final version of the manuscript being submitted. They warrant that the article is the authors' original work, hasn't received prior publication and isn't under consideration for publication elsewhere

Use of AI: During the preparation of this work the author(s) [Louca, C; Tonni, I; Leung, A; Fine, P] did not use AI in the preparation of this manuscript and take full responsibility for the content of the published article.

Author contributions: CRediT:

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