

Artificial intelligence chatbots and large language models in dental education: Worldwide survey of educators

Sergio E. Uribe^{1,2,3,4}  | Ilze Maldupa¹  | Argyro Kavadella⁵  | Maha El Tantawi⁶  |
Akhilanand Chaurasia^{4,7}  | Margherita Fontana⁸  | Rodrigo Marino⁹  |
Nicola Innes¹⁰  | Falk Schwendicke^{4,11} 

¹Department of Conservative Dentistry and Oral Health, Riga Stradins University, Riga, Latvia

²Faculty of Dentistry, Universidad de Valparaíso, Valparaíso, Chile

³Baltic Biomaterials Centre of Excellence, Headquarters at Riga Technical University, Riga, Latvia

⁴ITU/WHO Focus Group AI on Health, Topic Group Dental, Geneva, Switzerland

⁵School of Dentistry, European University Cyprus, Nicosia, Cyprus

⁶Faculty of Dentistry, Alexandria University, Alexandria, Egypt

⁷Department of Oral Medicine & Radiology, King George's Medical University, Lucknow, Uttar Pradesh, India

⁸Department of Cariology, Restorative Sciences and Endodontics, School of Dentistry, University of Michigan, Ann Arbor, Michigan, USA

⁹Melbourne Dental School, The University of Melbourne, Melbourne, Victoria, Australia

¹⁰School of Dentistry, College of Biomedical & Life Sciences, Cardiff University, Cardiff, UK

¹¹Department of Conservative Dentistry and Periodontology, Ludwig-Maximilians-University Munich, Munich, Germany

Correspondence

Sergio E. Uribe, Department of Conservative Dentistry and Oral Health Riga Stradins University, Dzirciema iela 20, LV-1007 Riga, Latvia.
Email: sergio.uribe@rsu.lv

Funding information

HORIZON EUROPE Framework Programme; Latvijas Zinātnes Padome

Abstract

Introduction: Interest is growing in the potential of artificial intelligence (AI) chatbots and large language models like OpenAI's ChatGPT and Google's Gemini, particularly in dental education. To explore dental educators' perceptions of AI chatbots and large language models, specifically their potential benefits and challenges for dental education.

Materials and Methods: A global cross-sectional survey was conducted in May–June 2023 using a 31-item online-questionnaire to assess dental educators' perceptions of AI chatbots like ChatGPT and their influence on dental education. Dental educators, representing diverse backgrounds, were asked about their use of AI, its perceived impact, barriers to using chatbots, and the future role of AI in this field.

Results: 428 dental educators (survey views = 1516; response rate = 28%) with a median [25/75th percentiles] age of 45 [37, 56] and 16 [8, 25] years of experience participated, with the majority from the Americas (54%), followed by Europe (26%) and Asia (10%). Thirty-one percent of respondents already use AI tools, with 64% recognising their potential in dental education. Perception of AI's potential impact on dental education varied by region, with Africa (4[4–5]), Asia (4[4–5]), and the Americas (4[3–5]) perceiving more potential than Europe (3[3–4]). Educators stated that AI chatbots could enhance knowledge acquisition (74.3%), research (68.5%), and clinical decision-making (63.6%) but expressed concern about AI's potential to reduce human interaction (53.9%). Dental educators' chief concerns centred around the absence of clear guidelines and training for using AI chatbots.

Conclusion: A positive yet cautious view towards AI chatbot integration in dental curricula is prevalent, underscoring the need for clear implementation guidelines.

KEYWORDS

artificial intelligence, chatbots, dental education, large language models, survey research, teaching methods

This is an open access article under the terms of the [Creative Commons Attribution](https://creativecommons.org/licenses/by/4.0/) License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2024 The Authors. *European Journal of Dental Education* published by John Wiley & Sons Ltd.

1 | INTRODUCTION

Artificial intelligence (AI) chatbots such as ChatGPT (Chat Generative Pre-Trained Transformer; OpenAI, San Francisco, United States) and Bard (Language Model for Dialogue Applications; Google, Mountain View, United States) have been identified as powerful and likely transformative tools in various domains, dental education being one of them. AI chatbots leverage large language models (LLMs) to generate coherent and contextually relevant text based on prompts. With a substantial user base of over 100 million, ChatGPT, for example, has experienced rapid growth and impacted communication and information access.¹

AI chatbots have demonstrated promise in supporting patient recommendations in medicine² and medical education^{3,4} comparable to a third-year medical student or first-year medical resident,⁵ these chatbots can provide relevant information on various medical topics, aiding in decision-making and enhancing clinical reasoning skills.⁶

The application of AI chatbots in dental education, which parallels the rapid growth of AI in dentistry post-2020, particularly in diagnostics, treatment planning, and telemedicine, has not yet been extensively explored. This highlights the need for curriculum updates in dental education to include advanced AI and deep learning approaches. Previous reports have highlighted the potential of IT to improve dental education, including e-learning, distance learning, simulation and computer-based assessment.⁷ For example, some dental educators use popular online platforms like YouTube^{8,9} and podcasts¹⁰ to share educational content, and the COVID-19 pandemic resulted in the widespread adoption of digital communication tools and e-learning and e-assessment methodologies.¹¹ A recent scoping review¹² underscores the potential of blended approaches in dental education, particularly e-learning technologies. This aligns with the European Association of Dental Education (ADEE) guidelines advocating IT as a supplementary tool in traditional teaching methods.¹³

Following these insights, AI chatbots like ChatGPT may emerge as potential disruptors, promising to enrich dental education with tailored, interactive learning experiences.¹⁴ However, some risks and challenges have also been identified for education, particularly in medicine.¹⁵ In the present study, we aimed to explore dental educators' insights about the potential of AI chatbots in dental education and to gather their perspectives on their feasibility, benefits, and challenges. This cross-sectional survey investigated global dental educators' views on artificial intelligence (AI) in dental education. The methodology included survey development with expert review and pilot testing, followed by a recruitment process through diverse channels. The survey, consisting of 31 items in eight sections, used multiple-choice, Likert scale, and open-ended questions to collect quantitative and qualitative data. Our findings provide insights for educators, policymakers, and researchers interested in leveraging innovative technological solutions to enhance dental education.

2 | MATERIALS AND METHODS

2.1 | Design and Ethics

This cross-sectional study, conducted via an online survey in May–June 2023, focused on gathering data from dental educators worldwide using a convenience sampling approach. The report follows the recommendations for Internet E-Surveys Reporting Guidelines (CHERRIES)¹⁶ (see [Table S1](#)). The study protocol was approved by the Ethical Committee of Riga Stradins University (2-PĒK-4/372/2023) and is available at <https://doi.org/10.17605/OSF.IO/5FESK>. Before participation, online informed consent was gathered, where participants were briefed about the survey length, data storage practices, investigator details, and study purpose. IP checks were performed to protect participant data to avoid multiple submissions from the same user. Only aggregated, anonymised data were used in the analysis.

2.2 | Development and pretesting

The survey development involved a multi-stage process. Initially, a range of question types focusing on the use and implications of AI in dental education was drafted in clear, jargon-free English. A panel of one AI and two dental education experts reviewed the survey for relevance and clarity, offering improvement suggestions.

The survey then underwent pilot testing with three different dental educators. None of these educators participated in the final survey. Feedback from these educators further refined the survey's design and functionality. Simultaneously, a technical verification was conducted on the Zoho Surveys platform to ensure seamless functioning across various devices and browsers and to verify the performance of interactive elements like checkboxes and drop-down lists. After gathering insights from pilot testing and technical testing, final revisions were made to the survey. Data collected during the development phase were excluded from the final analysis.

The survey comprised 31 items divided into eight sections. Section 1 gathered background information (six items). Section 2 explored the current use of AI in education based on the respondent's experience (four items). Section 3 examined the perceived impact of AI on dental education (three items). Section 4 focused on perceived barriers to using chatbots in dental education (six items). Section 5 discussed the future of AI chatbots in dental education (four items). Section 6 investigated the impact of AI tools on assessment methods in dental education (three items). Section 7 explored the impact of AI tools on student engagement, critical thinking, grading, and interaction in dental education (four items). The final section consisted of an open-ended question for additional feedback. Each section incorporated a combination of multiple-choice, Likert scale, and open-ended questions to capture quantitative and qualitative data. The final version of the survey is provided in the [Figure S1](#) and [Table S1](#).

2.3 | Recruitment and sample description

In May–June 2023, the research team disseminated the survey to personal contacts and professional associations via direct email, WhatsApp groups, and posts on professional networks on social media platforms such as Twitter and LinkedIn. The survey, open to any dental educators worldwide, was advertised with an offer to receive the final publication as an incentive for participation. Each participant provided written informed consent before the survey began. This study employed an exploratory, observational approach with convenience sampling without formal hypothesis testing.

2.4 | Survey administration

The web-based survey was distributed through Zoho Surveys, automatically capturing responses upon submission. A completeness check was incorporated into the survey design to ensure that only completed responses were included in the analysis. Respondents were allowed to review and modify their responses before final submission. The data collection period spanned from 24 May to 16 June 2023.

2.5 | Response rates

Unique site visitors were identified through IP checks. View, participation, and completion rates were calculated based on unique site visitors, unique visitors who filled in the first survey page, and unique users who completed the survey.

2.6 | Preventing multiple entries

Multiple submissions from the same individual were prevented through IP checks. No cookies or log file analyses were used, and no user registration was required to participate in this open survey.

2.7 | Analysis

Only completed questionnaires were considered for the analysis, and no submissions were excluded based on the duration it took to complete the survey. No weighting of items or propensity scores was used in this analysis. For the statistical analysis, we used R.¹⁷

3 | RESULTS

The survey was active for 25 days, from 24 May 2023 to 16 June 2023. It received a total of 1516 visits from participants. Of those visits, 428 individuals completed the survey, resulting in a response rate of 28%.

The median age of the respondents was 45 years, with a 25th/75th percentile range of 37–56 years. The median number of years of educational experience was 16, with a 25th/75th percentile range of 8 to 25 years. About half (53%) of the respondents identified as female, 47% as male, and 0.5% chose not to disclose their gender or identify as non-binary. The respondents represented 66 countries, with the highest proportion from the United States (21%), followed by Chile (15%) and Egypt (4%). Other countries had smaller percentages, ranging from 2.3% to 3.7%. Additionally, 28% of the respondents fell under the “Other” category, representing countries with less than 10 participants. The respondents were distributed across five continents, with 54% from the Americas, 26% from Europe, 9.8% from Asia, 7.2% from Africa, and 3% from Oceania (additional details in [Figure S1](#)). Most respondents self-classified as Professors (70.8%), followed by Lecturers (25%), Clinical Instructors (22%), and others (13.7%). As multiple roles could be chosen, percentages could exceed 100%. The respondents had a diverse range of areas of specialisation, with the highest percentages in paediatric dentistry (15.2%), dental public health (15%), and general dentistry (13.3%). As multiple areas could be chosen, percentages could exceed 100%. More information can be found in [Table 1](#).

Respondents rated their knowledge of AI-powered tools in education, such as ChatGPT, with a median score of 3 out of 5 (range: 1–5), indicating their familiarity on a scale from 1 (“not at all”) to 5 (“greatly”). The 25th/75th percentile ranged from 1 to 3. One-third of respondents (31.1%) used AI-powered tools, 44.4% stated otherwise, and 24.5% were uncertain. The most frequently used AI tools in education were ChatGPT, used for various tasks (24 mentions), and Turnitin, a plagiarism detection software (14 mentions). Tools such as Grammarly, oral/intraoral scanners, teledentistry, and AI dental solutions were each mentioned three times. Other tools were mentioned less than three times. More details are available in [Table S1](#).

In response to the question about their belief in AI chatbots enhancing dental education (rated from 1, “not at all,” to 5, “greatly”), the median score was 4, with a 25/75 percentile of 3–5, signifying a generally positive view of AI in dental education. When examined regionally, dental educators from Africa (4 [4–5]), Asia (4 [4–5]), and the Americas (4 [3–5]) reported higher median belief scores compared to those from Europe (3 [3–4]). In Oceania, with a limited participant pool of 13, the median score of 4 was underpinned by a broad score range of 2–5, suggesting diverse perceptions within this smaller respondent group. [Figure 1](#) presents a map with the median scores per country.

Educators believed AI could enhance dental education in knowledge acquisition (74.3%), research (68.5%), clinical decision-making (63.6%), assessment (60.0%), clinical skills training (38.8%), and other areas (10.0%), including administrative tasks, diagnostics, and critical decision-making. Respondents suggested AI use cases such as disease identification in images, evidence-based decision-making support, dental care management, content translation and summarising, personalised tutoring, collaborative work, and data analyses. More details are in [Table 2](#).

TABLE 1 Description of the participants.

Characteristic	N = 428 ^a
Age	45 (37, 56)
Years of Educational Experience	16 (8, 25)
Gender	
Female	226 (53%)
Male	200 (47%)
Prefer not to say/Non-binary	2 (0.5%)
Country	
United States	89 (21%)
Chile	65 (15%)
Egypt	17 (4.0%)
France	15 (3.5%)
United Kingdom	16 (3.7%)
Argentina	14 (3.3%)
Colombia	14 (3.3%)
Latvia	13 (3.0%)
Brazil	11 (2.6%)
Lithuania	11 (2.6%)
Mexico	11 (2.6%)
Spain	11 (2.6%)
India	10 (2.3%)
Venezuela	10 (2.3%)
Other	121 (28%)
Continent	
Africa	31 (7.2%)
Americas	231 (54%)
Asia	42 (9.8%)
Europe	111 (26%)
Oceania	13 (3.0%)
Role ^b	
Clinical Instructor	132 (22%)
Lecturer	150 (25%)
Other	82 (13.7%)
Professor	424 (70.8%)
Area specialization ^b	
Paediatric Dentistry	65 (15.19%)
Dental Public Health	64 (14.95%)
General Dentistry	57 (13.32%)
Cariology/Preventive Dentistry	55 (12.85%)
Restorative Dentistry	41 (9.58%)
Oral and Maxillofacial Radiology	36 (8.41%)
Orthodontics and Dentofacial Orthopaedics	33 (7.71%)
Basic Sciences	30 (7.01%)
Prosthodontics	29 (6.78%)
Periodontics	19 (4.44%)
Endodontics	15 (3.5%)

TABLE 1 (Continued)

Characteristic	N = 428 ^a
Oral Medicine	12 (2.8%)
Other-Nonclinical	12 (2.8%)
Oral and Maxillofacial Pathology	9 (2.1%)
Orofacial Pain or Temporomandibular Disorders	8 (1.87%)
Dental Anesthesiology	6 (1.4%)
Oral and Maxillofacial Surgery	6 (1.4%)
Other-Clinical	5 (1.17%)

^aMedian (IQR); n (%).

^bThe percentages may exceed 100% due to multiple options.

When surveyed about potential barriers to utilising AI tools like ChatGPT, 59.3% stated a lack of support or training, 50.2% doubted AI chatbots could replace traditional teaching, and 39.5% questioned chatbots' ability to assess students' skills. Forty-one percent believed the benefits of using AI tools outweighed the disadvantages, with 43.9% being neutral. Additionally, 44.9% found AI tools user-friendly. The details are in [Figure 2](#).

The main barriers to AI chatbots in dental education identified included resistance to change, knowledge gaps, fears of misuse, cost, accessibility, validity, reliability, mindset, ethics, and challenges like risks of plagiarism, bias, or lack of transparency. More details are in [Table 3](#).

Respondents expressed moderate comfort with AI tools in evaluation and assessment processes, scoring 3 out of 5 (25th to 75th percentile: 3–4). Key concerns involved AI's potential limitations in assessing critical thinking (32.5%), skills evaluation (22.5%), and loss of human interaction (20.8%), alongside data privacy issues (15.9%). Most participants saw increased grading efficiency (35.5%), consistency in assessment (32.9%), and personalised feedback (27.9%) as potential AI benefits. To enhance AI integration, respondents suggested more training for educators (35.2%), clear usage guidelines (33.7%), and AI inclusion in the curriculum (24.6%).

Participants anticipated that AI chatbots would notably influence various aspects of dental education, including grading, student engagement, feedback, interaction, and critical thinking. A significant proportion of respondents, 61.9%, agreed or strongly agreed that AI chatbots will modify the methods of assessment used in dental education. Specifically, respondents forecasted changes in the format of examinations and assignments; 41.5% and 46.9% strongly agreed that there would be a shift towards more oral assessments and fewer written assignments, respectively. Despite these potential advancements, 53.9% of respondents expressed concerns that such tools might decrease human interaction. Further details of the survey results are illustrated in [Figure 3](#).

Respondents shared their perspectives on AI in dental education in the final survey section. They showed keen interest and acknowledged AI's inevitable role in future education yet expressed concerns about their understanding and effective use of these tools. Many stressed the need for training and guidelines, especially on

Believe AI Chatbots can Enhance Dental Education?

Scale from 1 (Not at All) to 5 (Greatly), Median

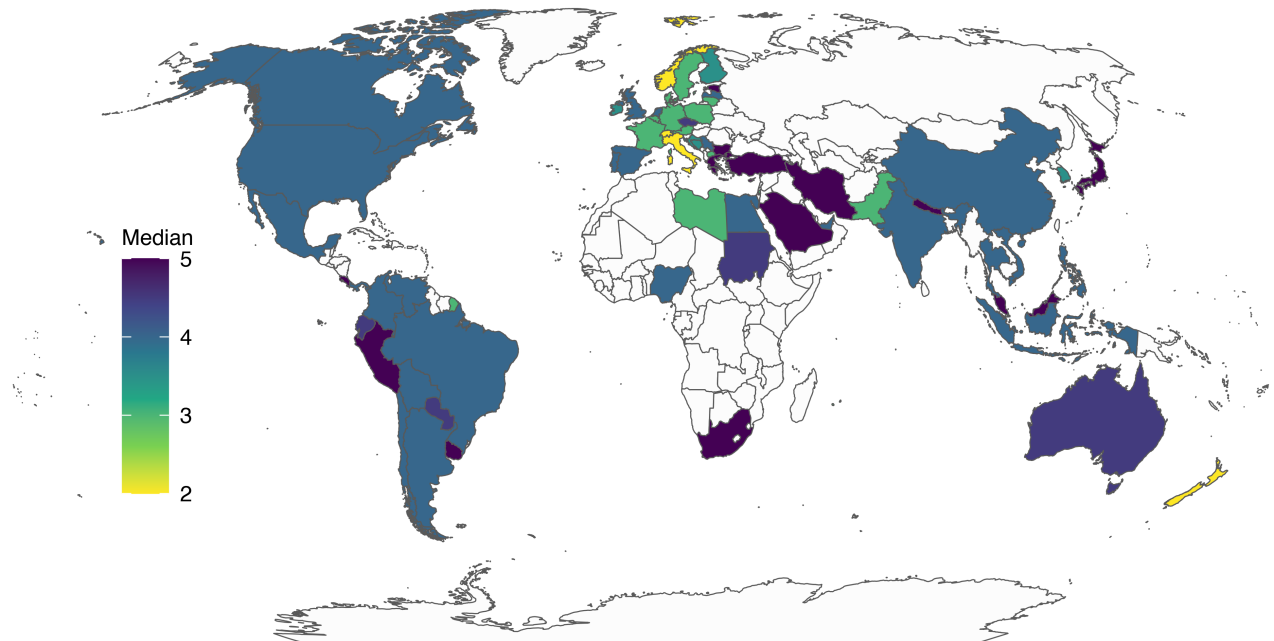


FIGURE 1 Global Map Showcasing Median Values of Dental Educators' Perceptions on the Potential of AI Chatbots to Enhance Dental Education.

ethical implications. Concerns ranged from potential depersonalisation to communication issues and fears of AI overpowering human roles. However, respondents were positive about AI's potential to reduce diagnostic errors, cater to varied learning paces, and enrich learning experiences. They called for responsible and ethical management of AI for dental education and requested clear guidance, training, and ethical considerations for its effective application.

4 | DISCUSSION

This study is the first survey assessing global dental educators' perspectives on adopting AI chatbots, such as ChatGPT,¹⁸ in dental education. Discussion around curriculum change through LLM chatbots is also evident in other areas of healthcare. Notably, there is a themed issue on the topic published in the JMIR, Journal of Medical Education, with papers on topics ranging from its revolutionary potential within the curriculum to improving its accessibility to medical educators.^{19,20} This activity and the perspectives are similar to those in this study, where participants recognise the potential for AI chatbots to significantly impact different aspects of dental education. However, they also expressed concerns regarding human interaction and developing critical thinking skills. One-third of respondents reported already using AI chatbot tools, predominantly ChatGPT. This aligns with the growing adoption of AI in education,³ hinting at a need for further training—particularly as half of the respondents rated their AI knowledge as mediocre or low.

The relatively low adoption rate and self-reported knowledge levels can be attributed, in part, to the recency of this technology; notably, ChatGPT was only launched less than a year before this survey (November 2022). Global educators participating in this survey acknowledge the potential of AI in dental education, with more positive perception ratings in Africa, Asia, and the Americas compared to Europe.²¹ The difference might be attributed to these regions' urgent demand for evidence-based tools and rapid technology assimilation. In contrast, European educators may be cautious due to entrenched teaching methodologies and longstanding, traditional infrastructures,²² the dynamic nature of AI technologies, or regulatory considerations.²³ Further hypothesis-driven research will help to understand these regional disparities.

Respondents perceived that AI chatbots' role would primarily enhance knowledge acquisition, research, and clinical decision-making, mirroring the broader medical education literature. However, less than 40% thought AI could enhance clinical skills training, reflecting concerns about AI's role in more practice-based dental education aspects.

The systematic review by Labadze et al.²⁴ (2023) emphasises significant challenges in implementing AI chatbots in dental education. Concerns include chatbot reliability, with potential misinformation dissemination due to incorrect responses, and the inconsistent accuracy and context relevance of responses, which hinders effective learning. Ethical concerns, notably regarding privacy and data security, are critical in dental education. Additionally, there is a risk of student over-reliance on AI, possibly impeding the development

TABLE 2 Summary of open-ended question: What are some potential scenarios where AI could play a role in dental education?

Category	Examples
Diagnosis and Treatment Planning	<ul style="list-style-type: none"> - Analysis, identification, and diagnosis of oral diseases in diagnostic images - Radiograph analysis - Clinical decision-making tools and support - Simulating cases and treatment planning - AI-based feedback for treatment documentation
Knowledge Acquisition	<ul style="list-style-type: none"> - Summarising content, creating mental diagrams - Facilitating information gathering, evidence-based literature access - Enhancing self-directed learning, clinical, research skills, and critical thinking - Error detection in dental care, risk management - Personalised tutoring, refining clinical judgement - Collaborative academic work - Transition guidance from preclinical to clinical settings - Immediate objective feedback on preparations - Analysing data for curriculum development
Patient Education	<ul style="list-style-type: none"> - Understanding treatments, oral health maintenance - AI-tools for patient communication and education - Personalised approach based on individual learning styles - Involving patients in treatment decisions - Enhancing patient understanding of diagnoses and outcomes - Oral hygiene practice recommendations - Facilitating patient communication, reminders for oral health maintenance - Enhancing patient compliance with treatment plans
Research	<ul style="list-style-type: none"> - Supporting research activities, guiding study design and statistical analysis - Assisting in literature search, evidence retrieval, data analysis, and interpretation - Assisting in manuscript writing, editing, and predicting outcomes - Supporting evidence-based research, generating assessment items - Assisting in experimental design, study interpretation

of critical thinking and problem-solving skills. Integrating chatbots into existing systems is complex, influenced by user attitudes and inadequate evaluation methods. Chatbots also struggle with

complex queries and maintaining response quality. The complexity of programming and maintaining educational chatbots requires substantial resources and expertise.²⁴ These issues highlight the need for cautious, strategic implementation of AI chatbots in dental education to balance potential benefits against these risks and limitations.

Integrating AI chatbots in dental education faces several barriers, including resistance to change, knowledge gaps among educators, potential misuse of these tools, cost and accessibility issues, validity and reliability concerns, ethical considerations, and technological limitations. The rapid development of AI in dental education, particularly in patient communication and research, highlights the need for curriculum updates to include AI literacy and address ethical and legal issues.⁷ Addressing these challenges requires suitable training, definitive guidelines, and robust institutional backing, initiatives some universities have already begun implementing.²⁵ Notably, none of the respondents mentioned potential job displacement due to AI implementation in their free-text responses. Although reports suggest significant human workforce reduction associated with AI introduction,²⁶ this was not a concern for these participants, possibly because dental educators are not plentiful, and given anticipated future workforce shortages,²⁷ the need for dental educators is likely to be expanded. The National Health Service (NHS-England) service plans corroborate this need, projecting a 20%–40% increase in programs for dental therapy, hygiene professionals, and dentists by 2028–2029.²⁸

In educational contexts, ChatGPT's utility for assignments and learning has been significant, allowing students to complete tasks with less effort and aiding non-native speakers in improving their writing to meet standards.²⁹ However, it has also raised privacy concerns due to data confidentiality issues,²⁹ and there is a risk of promoting incomplete understanding and potential academic dishonesty, such as plagiarism.³⁰ While some argue for its complementary role in various disciplines, as paediatric dentistry,³¹ others caution against overreliance due to its lack of human empathy and potential for incorrect or unspecific outputs.^{32,33} The need for human oversight, particularly in sensitive fields like healthcare, and the challenges of discerning AI-generated text highlight the importance of balanced integration of AI tools like ChatGPT in educational settings.³⁴

Respondents' moderate comfort with AI tools in evaluation and assessment processes implies reservations about AI's capability for assessing complex cognitive skills, data privacy, security, and the potential loss of human interaction. In 2008, projections for implementing information technologies anticipated a surge of "artificial intelligence, semantic networks, database-driven applications with built-in abilities to 'learn' from users."¹³ Notably, though, the primary motivation for implementing these technologies over the last decade was the COVID-19 pandemic,³⁵ which forced dental schools worldwide to modify traditional teaching³⁵ and assessment methods. The advent of ChatGPT appears to once again position educational institutions in a reactive role rather than spearheading change. Participants highlighted key areas for

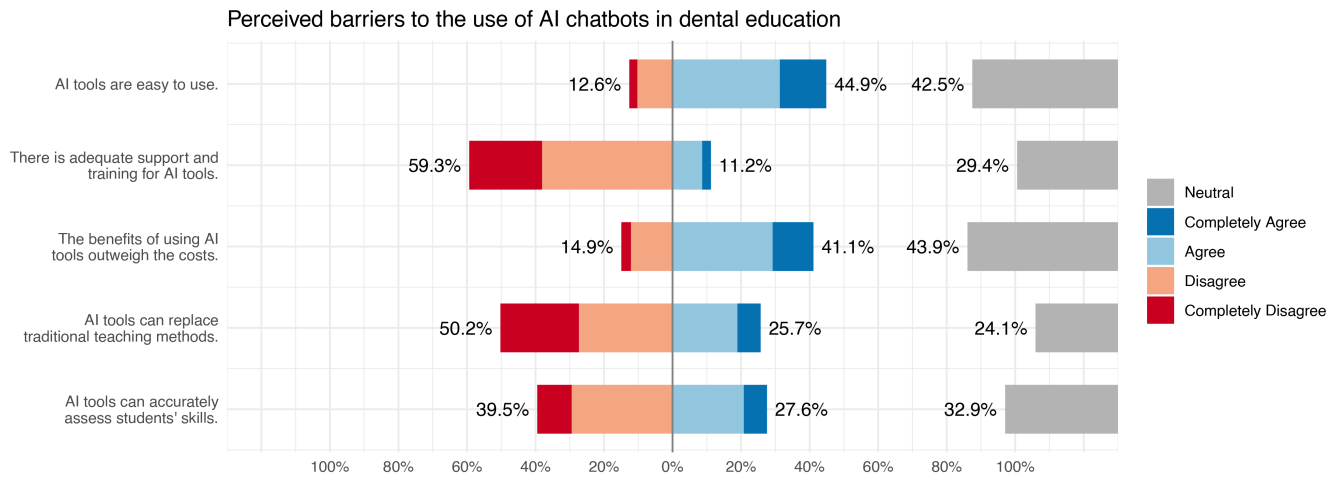


FIGURE 2 Perceived barriers to using AI chatbots in dental education.

TABLE 3 Summary of open-ended question: Perceived barriers to using chatbots AI in dental education.

Challenges	Examples
Resistance to Change	<ul style="list-style-type: none"> - Older educators' reluctance to adopt new technologies and change their teaching methods. - Lack of training and understanding among educators about AI tools and their effective use. - Entrenched beliefs and traditional pedagogies that hinder the application of AI and limit critical thinking and problem-solving skills.
Fear and Misuse	<ul style="list-style-type: none"> - Fear of plagiarism and concerns about students using AI tools to cheat or plagiarise. - Fear of incorrect use and the need to better understand AI technology. - Misuse of AI tools for research and assessment purposes.
Cost and Accessibility	<ul style="list-style-type: none"> - Financial constraints and the high cost of implementing AI technology in dental education. - Lack of access to secure and reliable AI programs, especially in developing countries. - Limited internet access and infrastructure in educational institutions.
Lack of Validity, Reliability, and Evidence	<ul style="list-style-type: none"> - Lack of a research base and evidence to support the use of AI in dental education. - Lack of validity and reliability studies on different educational AI tools.
Human Factors and Mindset	<ul style="list-style-type: none"> - Unwillingness of faculty to learn and adapt to new technologies. - Concerns about AI replacing human educators and patient interactions. - Lack of control and trust in AI tools and the need for human oversight.
Ethical Concerns	<ul style="list-style-type: none"> - Potential biases and errors in AI algorithms and the need for accreditation and evaluation of AI programs. - Lack of transparency in AI results and limitations in explaining algorithmic outputs.
Technological Limitations	<ul style="list-style-type: none"> - Current limitations of AI knowledge and its application in dental education. - Insufficient availability and variety of AI tools specifically designed for dental education.

Perceived Impact of AI Tools like ChatGPT on Student Engagement, Critical Thinking, Grading, and Interaction in Dental Education

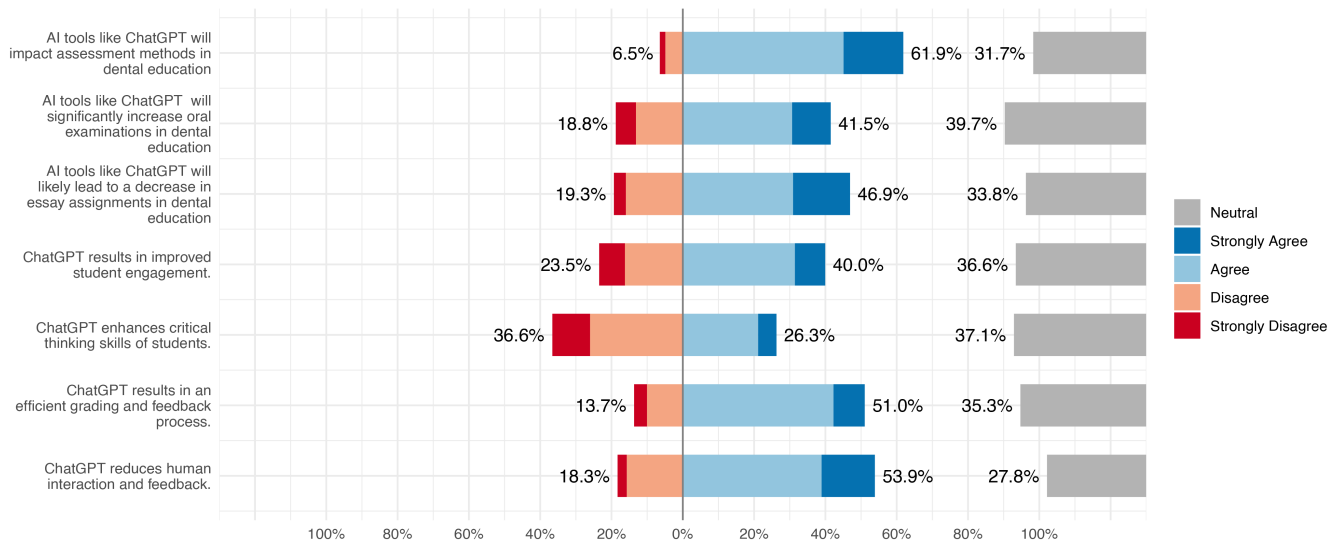


FIGURE 3 Perception of the impact of AI Chatbots in assessment, grading, engagement, critical thinking and interaction.

the appropriate use of AI systems in dental education, necessitating clear institutional guidelines. Concerns included routine student use of these systems for patient data input to validate diagnoses and treatment plans, patient data protection, and the need for institution-specific chatbots. Institutions must address these questions. A comprehensive guide and key recommendations for implementing AI in dental education have been published,³⁶ and perhaps better dissemination is needed. Additionally, it is crucial to critically equip dental students to assess AI literature supported by a helpful guide.³⁷ Recent studies indicate the potential of AI chatbots to enhance dental curricula,³⁸ improve caregivers' oral health knowledge,³⁹ and serve as effective clinical simulation tools,⁴⁰ yet highlight the need for ongoing research to comprehensively understand the impact of chatbot interaction on learning effectiveness and student satisfaction.⁴¹

AI Chatbots' integration into dental education hinges on addressing technical limitations like potential inaccuracies or "hallucinations" (i.e., AI's potential to fabricate false information), limited context comprehension, and its inability to learn from past interactions.^{42,43} Interestingly, ChatGPT has been investigated for how well it performs in the United States Medical Licensing exam and was found to be equivalent to a 3rd-year medical student in medical knowledge levels.⁴⁴ Although 61.9% of respondents see AI revolutionising student evaluations, only 26.3% believe it can enhance critical thinking, indicating a need for further research. This confirms prior findings that students primarily use new information technologies to transmit, store, or memorise class content rather than expand, complement, or critically evaluate it.⁴⁵ Continued research is necessary to explore how AI can effectively contribute to developing critical thinking skills in dental students. As evidenced in other educational settings,⁴⁶ the arrival of ChatGPT has prompted a reconsideration of traditional teaching and assessment,⁴⁷ advocating for an approach that emphasises interactivity and understanding over

rote learning. Integrating AI Chatbots into dental education could offer significant benefits by allowing for a near 1:1 tutor-to-student ratio, as exemplified in courses like Harvard's CS50⁴⁸ and other benefits like aiding clinical decision-making, managing schedules, facilitating brainstorming, and personalising learning.⁶ This approach provides learners with personalised support tools around the clock, enhancing their learning at their pace and style. However, alongside these advantages, it is crucial to consider ethical issues, particularly regarding patient data privacy and the potential misuse of clinical information. Institutions need clear guidelines to ensure that the use of AI tools is carried out responsibly without compromising patient confidentiality. It is pertinent to note that while OpenAI reported improved GPT-4's ability to answer medical test questions, increasing content restrictions may limit its application in medical education.⁴² Therefore, balancing content relevance and avoiding sensitive topics is critical for effectively utilising AI chatbots in educational settings.

AI chatbots like ChatGPT can transform learning and information synthesis, but addressing concerns such as biases and automation overreliance is essential.⁴⁹ The development of SciEdBERT,⁵⁰ an education-focused language model, suggests the potential for domain-specific LLMs in dental education. These LLMs can be fine-tuned using institution-specific materials for 24/7/365 student support. Questions on models' transferability and performance necessitate further research. Future studies should compare AI chatbot models like Bard and ChatGPT 4.0 in dental education and evaluate student perceptions of AI's value and limitations for effective integration. AI can be academically challenging but offers benefits like organisational assistance and enhanced learning experiences.⁴³ The true value of AI in education lies in balancing its potential to augment human capabilities with an awareness of its limitations, thus preparing students for a future increasingly influenced by AI.

To effectively integrate AI tools like ChatGPT into dental education, practical recommendations include⁵¹ the following:

1. *Interactive role-playing*: Use ChatGPT for role-playing exercises where students interact with AI as patients, encouraging critical thinking and scenario-based learning.
2. *Curriculum development*: Use ChatGPT to create quizzes, lesson plans and tests on various dental topics, streamlining the creation of educational content.
3. *Language support*: Leverage ChatGPT's translation capabilities to assist non-native English speakers, supporting language skills critical in dentistry.
4. *Improve critical thinking*: Incorporate ChatGPT responses to prompt students to verify information with reliable sources, such as clinical guidelines, to assess the reliability of the chatbot and develop critical thinking skills.
5. *Customised lesson plans*: Use ChatGPT to customise lesson plans on specific dental topics, such as implants or orthodontics, based on teaching objectives and student knowledge levels.
6. *Enhanced explanations*: Use ChatGPT to create clear and effective explanations, examples and analogies in dental science to improve student understanding.
7. *Learning by Teaching*: Have students evaluate explanations generated by ChatGPT, taking on the role of the AI student, to deepen their understanding of dental topics.
8. *AI tutoring*: Implement ChatGPT as an AI tutor, providing personalised explanations and guidance based on individual student needs and knowledge levels.

To inform the appropriate use of chatbots such as ChatGPT in dental education, the general guidance provided in Figure 4 can be used. This structured approach to determining when it is safe, possible, or unsafe to use chatbots is based on factors such as the need for truthful output, the availability of experts to verify accuracy, and the willingness to take responsibility for using content. This framework can be a valuable reference when integrating AI chatbots in educational settings.



Modified from
Aleksandr
Tiulkanov, AI and
Data Policy Lawyer,
January 2023

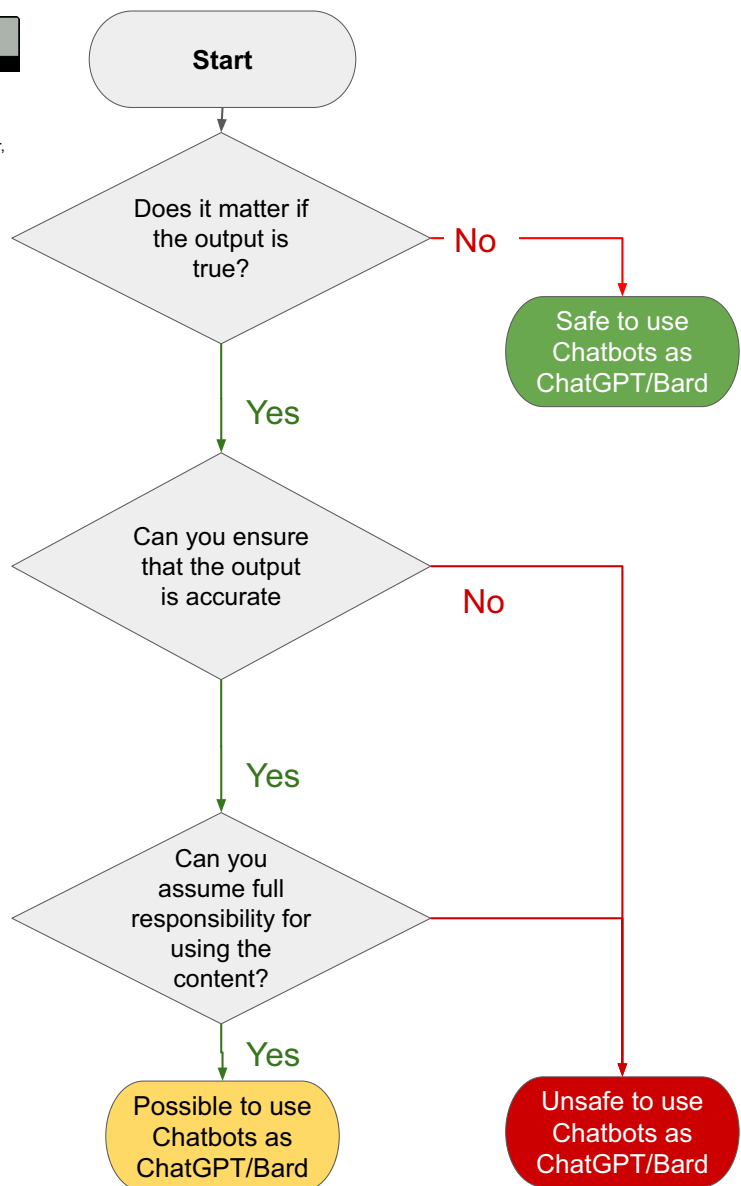


FIGURE 4 Guidelines for Optimal and Responsible Use of AI Chatbots in Dental Education. [Correction added on 1 May 2024 after first online publication: Figure 4 was updated with a revised version]

Our study has some limitations. The web survey method may introduce bias to the results due to potential self-selection bias,⁵² which should be considered in future studies. However, our response rate falls within the expected range of 25%–35% for online surveys.⁵³ Our sample of dental educators across continents and specialisations provides broad, albeit preliminary, insights into AI chatbots in dental education. The results should be considered preliminary and exploratory, serving as a baseline for future studies. Conducting studies using probability sampling and comparing expectations with outcomes after years of AI chatbot use in dental education is recommended. In addition, the pilot study involved a limited number of experts selected for their expertise in question development. While this was considered sufficient for this exploratory study, future research may benefit from a more extensive pilot study with a larger and more diverse panel of experts to increase the validity and comprehensiveness of the survey instrument. Our survey design has limitations in interpreting results as we balanced comprehensive and concise questions for engagement within an average completion time of 9 min, which led to some areas needing more clarity. This brief questionnaire provides a foundation for future research to explore AI's role in dental education extensively. Our findings should be a foundation for future studies rather than definitive conclusions.

5 | CONCLUSION

This survey reveals dental educators' perspectives on AI chatbots like ChatGPT in dental education, highlighting a potential transformative shift. The integration offers an opportunity to align dental curricula with broader healthcare education, fostering a patient-centred approach and enhanced critical thinking. However, to realise this potential, it is crucial to address the challenges identified, particularly the faculty's concerns. Rigorous evaluation of AI chatbots' impact and developing proper implementation guidelines are essential. Ultimately, integrating AI transcends mere technology adoption, preparing future dental professionals for a digitally evolving healthcare landscape.

AUTHOR CONTRIBUTIONS

Conceptualization: S.E.U. and I.M.; Data curation: S.E.U. and I.M.; Formal analysis and project administration: S.E.U.; Funding acquisition: S.E.U. and I.M.; Investigation: S.E.U., I.M., A.K., M.E.T., A.C., M.F., R.M., N.I., and F.S.; Methodology: S.E.U., I.M.; Writing – original draft: S.E.U.; Writing – review and editing: S.E.U., I.M., M.E.T., A.C., M.F., R.M., N.I., and F.S.

ACKNOWLEDGEMENTS

SEU acknowledges financial support from the European Union's Horizon 2020 research and innovation program under grant agreement No 857287 for the Baltic Biomaterials Centre of Excellence. IM, NI, RM, and SEU acknowledge financial support from The Latvian Council of Science, project No Izp-2.

022/1-0047, "IEVA Project." We sincerely thank all our colleagues around the globe who generously devoted their time to participate in this survey and for their efforts in sharing it with their contacts.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data and analysis scripts supporting this research's results are available here: Uribe, Sergio & Maldupa, Ilze. Worldwide Survey on the Impact of AI Chatbots and Large Language Models in Dental Education: Insights from Dental Educators [Data set]. Zenodo. <https://doi.org/10.5281/zenodo.8074534>

ORCID

Sergio E. Uribe  <https://orcid.org/0000-0003-0684-2025>

Ilze Maldupa  <https://orcid.org/0000-0002-5967-956X>

Argyro Kavadella  <https://orcid.org/0009-0003-0560-8373>

Maha El Tantawi  <https://orcid.org/0000-0003-4989-6584>

Akhilanand Chaurasia  <https://orcid.org/0000-0002-8356-9512>

Margherita Fontana  <https://orcid.org/0000-0003-2357-7534>

Rodrigo Marino  <https://orcid.org/0000-0002-3061-843X>

Nicola Innes  <https://orcid.org/0000-0002-9984-0012>

Falk Schwendicke  <https://orcid.org/0000-0003-1223-1669>

REFERENCES

1. ChatGPT sets record for fastest-growing user base-analyst note. *Reuters*. Thomson Reuters Corporation; 2023; Published online Feb 2. Accessed June 17, 2023. <https://www.reuters.com/technology/chatgpt-sets-record-fastest-growing-user-base-analyst-note-2023-02-01/>
2. Ayers JW, Poliak A, Dredze M, et al. Comparing physician and artificial intelligence Chatbot responses to patient questions posted to a public social media forum. *JAMA Intern Med*. 2023; published online April 28;186(6):589-596. doi:10.1001/jamainternmed.2023.1838
3. Lee H. The rise of ChatGPT: exploring its potential in medical education. *Anat Sci Educ*. 2023; published online March 14;1-6. doi:10.1002/ase.2270
4. Arif TB, Munaf U, Ul-Haque I. The future of medical education and research: is ChatGPT a blessing or blight in disguise? *Med Educ Online*. 2023;28:2181052.
5. Humar P, Asaad M, Bengur FB, Nguyen V. ChatGPT is equivalent to first year plastic surgery residents: evaluation of ChatGPT on the plastic surgery in-service exam. *Aesthet Surg J*. 2023; published online May 4.;43:NP1085-NP1089. doi:10.1093/asj/sjad130
6. Kung TH, Cheatham M, Medenilla A, et al. Performance of ChatGPT on USMLE: potential for AI-assisted medical education using large language models. *PLOS Digit Health*. 2023;2:e0000198.
7. 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;13:150.
8. Dias da Silva MA, Pereira AC, Vital S, et al. Online videos: the hidden curriculum. *Eur J Dent Educ*. 2022;26:830-837.
9. Mukhopadhyay S, Kruger E, Tennant M. YouTube: a new way of supplementing traditional methods in dental education. *J Dent Educ*. 2014;78:1568-1571.
10. Sethi N, Lettelleir J, Mays KA. Incorporation of podcast as an adjunctive study material for national board examination: a preliminary

- study. *J Dent Educ*. 2023; published online March 30;87:1042-1046. doi:10.1002/jdd.13204
11. Quinn B, Field J, Gorter R, et al. COVID-19: the immediate response of European academic dental institutions and future implications for dental education. *Eur J Dent Educ*. 2020;24:811-814.
 12. Di Carvalho ML, Bastos Silveira B, Amorim Dos Santos J, et al. Dental education profile in COVID-19 pandemic: a scoping review. *Eur J Dent Educ*. 2023;27:252-261.
 13. Mattheos N, Stefanovic N, Apse P, et al. Potential of information technology in dental education. *Eur J Dent Educ*. 2008;12 Suppl 1:85-92.
 14. Eysenbach G. The role of ChatGPT, generative language models, and artificial intelligence in medical education: a conversation with ChatGPT and a call for papers. *JMIR Med Educ*. 2023;9:e46885.
 15. Kooli C. Chatbots in education and research: a critical examination of ethical implications and solutions. *Sustain Sci Pract Policy*. 2023;15:5614.
 16. Eysenbach G. Improving the quality of web surveys: the checklist for reporting results of internet E-surveys (CHERRIES). *J Med Internet Res*. 2004;6:e34.
 17. R Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing; 2021. <http://www.R-project.org/>
 18. Lee P, Bubeck S, Petro J. Benefits, limits, and risks of GPT-4 as an AI Chatbot for medicine. *N Engl J Med*. 2023;388:1233-1239.
 19. Abd-Alrazaq A, AlSaad R, Alhuwail D, et al. Large language models in medical education: opportunities, challenges, and future directions. *JMIR Med Educ*. 2023;9:e48291.
 20. Mesko B. The ChatGPT (generative artificial intelligence) revolution has made artificial intelligence approachable for medical professionals. *J Med Internet Res*. 2023;25:e48392.
 21. Cesareo S, White J, Mostrous A. The global artificial intelligence index. Tortoise. 2023; published online June 28. Accessed June 30, 2023. <https://www.tortoisemedia.com/2023/06/28/the-global-artificial-intelligence-index/>
 22. Pruvot EB, Estermann T, Popkhadze N. *University Autonomy in Europe IV: the Scorecard 2023*. European University Association, 2023. Accessed July 3, 2023. <https://bit.ly/44ad8aP>
 23. Khatsenkova S. The EU's AI act: a guide to understanding the ambitious plans to regulate artificial intelligence. Euronews. 2023; published online May 15. Accessed June 30, 2023. <https://www.euronews.com/next/2023/05/15/the-eus-ai-act-a-guide-to-understanding-the-ambitious-plans-to-regulate-artificial-intelli>
 24. Labadze L, Grigolia M, Machaidze L. Role of AI chatbots in education: systematic literature review. *Int J Educ Technol High Educ*. 2023;20:1-17.
 25. New principles on use of AI in education. *The Russell Group*. 2023. Accessed July 5, 2023. <https://russellgroup.ac.uk/news/new-principles-on-use-of-ai-in-education/>
 26. Shine I, Whiting K. These are the jobs most likely to be lost—and created—because of AI. World Economic Forum. 2023; published online May 4. Accessed June 28, 2023. <https://www.weforum.org/agenda/2023/05/jobs-lost-created-ai-gpt/>
 27. Try G. Too few dentists? Workforce planning 1996–2036. *Prim Dent Care*. 2000;7:9-13.
 28. NHS-England. *NHS Long Term Workforce Plan*. NHS, 2023. Accessed July 10, 2023. <https://dentistry.co.uk/wp-content/uploads/2023/06/nhs-long-term-workforce-plan.pdf>
 29. Eggmann F, Weiger R, Zitzmann NU, Blatz MB. Implications of large language models such as ChatGPT for dental medicine. *J Esthet Restor Dent*. 2023; published online April 5;35:1098-1102. doi:10.1111/jerd.13046
 30. Huh S. Are ChatGPT's knowledge and interpretation ability comparable to those of medical students in Korea for taking a parasitology examination?: a descriptive study. *J Educ Eval Health Prof*. 2023;20:1.
 31. Vishwanathaiah S, Fageeh HN, Khanagar SB, Maganur PC. Artificial intelligence its uses and application in pediatric dentistry: a review. *Biomedicine*. 2023;11:11. doi:10.3390/biomedicines11030788
 32. Strunga M, Urban R, Surovková J, Thurzo A. Artificial intelligence systems assisting in the assessment of the course and retention of orthodontic treatment. *Healthcare (Basel)*. 2023;11:11. doi:10.3390/healthcare11050683
 33. Selvan P, Thavarajah R, Ranganathan K. NLP and oral health information. *J Oral Maxillofac Pathol*. 2023;27:15-17.
 34. Alhaidry HM, Fatani B, Alrayes JO, Almana AM, Alhaaed NK. ChatGPT in dentistry: a comprehensive review. *Cureus*. 2023;15:e38317.
 35. Trivandrum Anandapadmanabhan L, Ramani P, Ramadoss R, Panneerselvam S, Sundar S. Effect of COVID-19 on dental education: a review. *Cureus*. 2022;14:e24455.
 36. Schwendicke F, Chaurasia A, Wiegand T, et al. Artificial intelligence for oral and dental healthcare: core education curriculum. *J Dent*. 2023;128:104363.
 37. Schwendicke F, Singh T, Lee J-H, et al. Artificial intelligence in dental research: checklist for authors, reviewers, readers. *J Dent*. 2021;107:103610.
 38. Suárez A, Adanero A, Díaz-Flores García V, Freire Y, Algar J. Using a virtual patient via an artificial intelligence Chatbot to develop dental Students' diagnostic skills. *Int J Environ Res Public Health*. 2022;19:148735. doi:10.3390/ijerph19148735
 39. Pithpornchaiyakul S, Naorungroj S, Pupong K, Hunsrisakhun J. Using a Chatbot as an alternative approach for in-person Toothbrushing training during the COVID-19 pandemic: comparative study. *J Med Internet Res*. 2022;24:e39218.
 40. Kaur A, Singh S, Chandan JS, Robbins T, Patel V. Qualitative exploration of digital chatbot use in medical education: a pilot study. *Digit Health*. 2021;7:20552076211038151.
 41. Stathakarou N, Nifakos S, Karlgren K, et al. Students' perceptions on Chatbots' potential and design characteristics in healthcare education. *Stud Health Technol Inform*. 2020;272:209-212.
 42. OpenAI. GPT-4 technical report. *arXiv [csCL]*. 2023; published online March 15. <http://arxiv.org/abs/2303.08774>
 43. Howell CW. Don't want students to rely on ChatGPT? Have them use it. *Wired*. 2023; published online June 6. Accessed June 15, 2023. <https://www.wired.com/story/dont-want-students-to-rely-on-chatgpt-have-them-use-it/>
 44. Gilson A, Safranek CW, Huang T, et al. How does ChatGPT perform on the United States medical licensing examination? The implications of large language models for medical education and knowledge assessment. *JMIR Med Educ*. 2023;9:e45312.
 45. Uribe S, Mariño RJ. Internet and information technology use by dental students in Chile. *Eur J Dent Educ*. 2006;10:162-168.
 46. Ceres P. ChatGPT is coming for classrooms. Don't panic. *Wired*. 2023; published online Jan 26. Accessed June 7, 2023. <https://www.wired.com/story/chatgpt-is-coming-for-classrooms-dont-panic/>
 47. Giannakopoulos K, Kavarella A, Kavvadia K, Yiallouris A, Kaklamanos EG. Dental students' and faculty perception of online exams with e-invigilation in Cyprus. *Eur J Dent Educ*. 2023; published online March 30;27:1098-1108. doi:10.1111/eje.12903
 48. CS50 Will Integrate Artificial Intelligence Into Course Instruction. Accessed June 29, 2023. <https://www.thecrimson.com/article/2023/6/21/cs50-artificial-intelligence/>
 49. Artificial Intelligence: UNESCO publishes Policy Paper on AI Foundation Models. 2023; published online June 15. Accessed June 16, 2023. <https://www.unesco.org/en/articles/artificial-intelligence-unesco-publishes-policy-paper-ai-foundation-models>
 50. Beltagy I, Lo K, Cohan A. SciBERT: a pretrained language model for scientific text. *arXiv [csCL]*. 2019; published online March 26. <http://arxiv.org/abs/1903.10676>
 51. Sabzalieva E, Valentini A. *ChatGPT and Artificial Intelligence in Higher Education: Quick Start Guide*. UNESCO; 2023.

52. Bethlehem J. Selection bias in web surveys. *Int Stat Rev.* 2010;78:161-188.
53. Sheehan KB. E-mail survey response rates: a review. *J Comput Mediat Commun.* 2001;6(2):JCMC621. doi:[10.1111/j.1083-6101.2001.tb00117.x](https://doi.org/10.1111/j.1083-6101.2001.tb00117.x)

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Uribe SE, Maldupa I, Kavadella A, et al. Artificial intelligence chatbots and large language models in dental education: Worldwide survey of educators. *Eur J Dent Educ.* 2024;28:865-876. doi:[10.1111/eje.13009](https://doi.org/10.1111/eje.13009)