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## RESEARCH ARTICLE

# Artificial Intelligence in Dentistry: Knowledge and Perceptions of Moroccan Students

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## Abstract

**Introduction:** Artificial intelligence (AI) is a revolution in education, research and health. The aim of this study is to assess the views and perceptions of dental students regarding artificial intelligence and its impact on their future professional practice.

**Methods:** A voluntary anonymous e-questionnaire was sent to all 4th and 5th year dental students of the Faculty of Dentistry after receiving a course on artificial intelligence. The questionnaire consisted of sections to assess students' knowledge of artificial intelligence and its possible applications in dentistry as well as ethical considerations. Statistical analysis of the data was carried out using SPSS version 23 software.

**Results:** A total of 149 students out of 187 (71.4% female and 28.9% male) responded to the questionnaire, i.e. a response rate of 79.67%; the average age was 22 years  $\pm$  1.014. Thus 43.50% of the students were not aware of artificial intelligence in general and 73.7% did not know its application in dentistry before the course. 43.18% totally agreed that artificial intelligence is a gain in dentistry while only 25.37% were very concerned about it in professional dental practice. 44.77% of the participants strongly agreed that ethical considerations should be taken into account when applying artificial intelligence in dentistry. Comparing the mean scores of students' knowledge of AI before the course (1.71/4) and after the course (2.40/4), the course significantly improved their knowledge ( $p = 0,00$ ).

**Conclusion:** Although the students have insufficient knowledge of artificial intelligence, they are interested in increasing their knowledge. They remain optimistic about the positive impact of artificial intelligence can have on their future dental exercise.

**Keywords:** Deep learning, Artificial intelligence, Machine learning

## 1. Introduction

Artificial intelligence is a major technological advance and represents a fourth industrial revolution [1]. John McCarthy coined the term artificial intelligence in 1955. He defined it as “the science and engineering of making intelligent machines”. It is therefore a computer science that relies on software and algorithms to imitate and reproduce human intelligence in terms of reasoning, task planning, learning and communication [2]. The advent of machine learning and deep learning has made artificial intelligence capable of reproducing and even surpassing the human

cognitive process [3]. There are many applications of artificial intelligence that improve (smartphone, voice and facial recognition, text translation, spam filters, travel guides) [4–6].

The field of health has also been infused with artificial intelligence [3,5], with countless applications allowing clinicians to provide quality care in terms of effectiveness, efficiency and accuracy, thus reducing the risk of error due to the exhaustion of healthcare professionals [7–10]. This technology simplifies complex protocols, provides predictable results and allows for better productivity by automating time-consuming tasks [1,3,5,11]. According to the American Medical Association's 2018 report,

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artificial intelligence has taken on the role of an assistant that enhances the expertise of healthcare professionals and has the ambition to make healthcare safer, more accessible, more equitable and more affordable in terms of overall cost [7,11]. While the most popular application of artificial intelligence is in the field of radiology” [1], it nevertheless covers a wide range of medical specialties [8,10,12,15]. This technology also plays a role in the clinical and pre-clinical training of students [1,10]. Artificial intelligence also allows remote diagnosis of patients who lives far from health care centers and could solve the problem of human resource shortages predicted by the World Health Organisation (WHO) since 2017 [10].

Dentistry has also been able to take advantage of artificial intelligence advances to ensure good communication with patients, appointment scheduling, dental radiological exploration, computer-assisted diagnosis of hard and soft tissue dental pathologies, treatment planning, evaluation of therapeutic decisions, survival prediction of patients with oral cancers [6,7,9,13,14]. The general consensus seems to be that it is only a matter of time before the many applications of this innovative technology permeate the health sciences and dentistry in particular [5]. The WHO strongly recommends that health professionals understand the basic functioning of artificial intelligence in order to make full and appropriate use of its broad [8,13]. Lack of information or misinformation about the role of artificial intelligence could lead to reluctance and negative attitudes or even theories of replacing the medical profession by the machine [10,13,15].

As artificial intelligence is not yet fully established in Morocco and aware that it will have the greatest impact on the next generation of dentists, the deanship of the Faculty of Dentistry at the Mohammed VI University of Sciences and Health (UM6SS) in Casablanca has integrated a course on this technology into the initial training of students as part of an opening module. Thus the 4th and 5th year students received two face-to-face interactive guided teaching sessions of 1h30 over 2 sessions for each respective level. These courses were delivered by a permanent teacher at the faculty of dentistry who is one of the auteur. This teaching is focused on the basic principles of artificial intelligence and a non-exhaustive overview of its fields of application in dentistry. The sessions were an opportunity for exchanges and debates on the applications of this technology but also the positive contributions and possible fears that the use of artificial intelligence in dentistry provides. The courses were then sent to the students on a course hosting platform. This

course was subject at the end of the first semester to a summative evaluation.

The aim of this work is to evaluate the views and perceptions of 4th and 5th year dental students who have received the course on artificial intelligence and its impact on their future practice.

## 2. Material and methods

**Study design:** This is a descriptive and exhaustive cross-sectional epidemiological performed at the Faculty of Dentistry at the UM6SS during the academic year 2022–2023.

**Sample size:** all 4th and 5th year students having received a course on artificial intelligence and its application in dentistry are included in this survey.

**Data collection:** A voluntary, anonymous, self-administered e-questionnaire was then carried out, based on a modified version of the Bisdas study [12]. This questionnaire is in French, as dental studies in Morocco are mainly conducted in French. The survey was pre-tested and refined with a group of 6th year students to check the comprehension of the items and to evaluate the time needed to fill it in, and then it was sent via the institutional email to all 4th and 5th year students. The questionnaire consisted of 6 sections in the form of questions, the answers to which were evaluated according to the 4-level Likert scale. The first section was dedicated to demographic data (age, gender, level of education). The second part explored the mastery of the computer tool, the third part assessed the understanding of the basic principles of AI, while the fourth session focused on the knowledge of artificial intelligence's applications in dentistry. The fifth and sixth sections respectively collected students' positive feelings and concerns about it. The need for ethical consideration was also questioned by the students as well as the need for training in artificial intelligence.

**Data analysis:** The statistical analysis of the data was carried out by the software SPSS version 23 with the descriptive statistical analysis (mean, standard deviation, frequency), the means of knowledge were compared using the t-test for paired samples and the significance was assessed at the  $p < 0.05$  level.

Ethical considerations were respected during this survey, thus in accordance with the 1964 Declaration of Helsinki, participation was entirely voluntary without any direct or indirect compensation and the data collection was entirely anonymous. All respondents gave their informed consent after being informed of the nature and purpose of the survey, the access to the data was only allowed to the principal investigator.

### 3. Results

A total of 149 out of 187 students (71.4% female and 28.9% male) responded to the questionnaire, i.e. a response rate of 79.67%. The average age was 22 years  $\pm$  1.014.

The internal consistency of the questionnaire was evaluated using Cronbach's alpha, its calculated value of 0.86 corresponds to a good homogeneity and internal consistency of our questionnaire. For the descriptive statistics, the categories “strongly disagree” and “disagree” were summarized as disagreement, while “agree” and “strongly agree” were summarized as agreement. Thus 85.9% of the students were interested in computer technology; however, only 32.88% of the students really mastered it. In terms of general knowledge of artificial intelligence, 43.6% of our students did not know the basic principle of AI before the course, 69.1% of the students did not know his applications in everyday life, 65.1% did not know about applications in education, and 65.8% were unaware that this technology research in the health sciences has attracted the most investment worldwide.

Regarding their source of information on artificial intelligence, 26.8% knew about AI through the university, 19.5% through friends and 10.1% through the media and 29.5% through multiple sources.

Regarding the dental applications of AI, 73.2% of the students did not know about them before the course and 49.54% of them understood them after the course; 77.78% of the students agreed that artificial intelligence is a gain for dental practice but 59.89% had high to moderate concerns about it. The majority (76.18%) agreed with the need for ethical considerations in the use this technology. While 62.4% of the students reported a good to very good understanding after the AI course, indeed by comparing the mean scores of students' knowledge of AI before the course (1.71/4) and after the course (2.40/4), the course significantly improved their knowledge ( $t = -12.66$   $p = 0.00$ ) and 96.6% of students wanted to receive further training in AI. The results are shown in [Table 1](#), [2](#), [3](#), [4](#) and [Fig. 1](#).

### 4. Discussion

Artificial intelligence is growing exponentially, invading different areas of health sciences including dentistry. The current students, dentists of tomorrow will be really impacted during their professional practice, and therefore, they must be initiated in order to be ready and able to use it effectively. To our knowledge, this is the first survey

Table 1. Socio-demographic data.

	Number	Percentage:%
Sex		
Male	43	28,9
Female	106	71,1
Age		
20-21	33	22,1
22-23	103	69,1
24-26	13	8,72
Level of study:		
Fourth years	30	20,1
Fifth years	119	79,9

Table 2. Students' Mastery of computer tools.

	Disagree	Agree
Mastery of office automation	42,9	57,1
Assessment of the reliability of information	32,9	67,1
Knowledge of computer security	78,6	21,4
Website development	87,9	12,1
Programming languages	93,3	6,7
TOTAL	67,12%	32,88%

Table 3. Student's Knowledge before and after the IA courses.

	Disagree	Agree
<b>Knowledge before the IA course:</b>		
Basic concept of AI	43,6	56,4
Basis of operation of AI	40,9	59,1
Applications in everyday life	69,1	30,9
Application in dentistry	83,2	16,8
Application in education	65,1	34,9
the highest investment in AI is in the health sciences	65,8	34,2
TOTAL	62,25%	37,75%
<b>Knowledge after the IA course</b>		
Basis of operation of AI in dentistry	37,5	62,5
Practice management and communication	51,7	48,3
Diagnostic assistance	45	55,1
Prescription drugs	64,5	35,6
Therapeutic decision support	54,3	45,6
Help with the clinical act	49,6	50,3
Help and working partner	23,5	76,5
TOTAL	50,46%	49,54%

conducted in Morocco among dental students in order to collect their knowledge and perceptions of artificial intelligence. The results of this survey indicate that more than half of the students have already heard of AI but that in general 62.25% had limited knowledge of artificial intelligence both in terms of its working principle, its applications in everyday life and its applications in dentistry. This lack of knowledge of the basics of this technology among health professionals has been found in studies of various nationalities [1,6,9,10,13,15]. It is true that being from a less-developing country could be a barrier to understanding artificial

Table 4. Students' positive perception and concerns about artificial intelligence.

	Disagree	Agree
<b>Positive perception of IA:</b>		
Great revolution	12,1	87,9
Better communication	43,6	56,4
Improved diagnosis	14,1	85,9
Optimised workflow	13,4	86,6
Time saving	12	86
Automation of repetitive tasks	20,8	79,2
Data sharing	24,9	40,1
Exciting dental medicine	35,6	64,4
Help and working partner	23,5	76,5
TOTAL	22,22%	77,78%
<b>Concerns about AI:</b>		
Fear of technology	67, 8	32,8
Cybersecurity and data leakage	29,5	70,5
Protection of personal data	30,2	68,8
Fear of replacement	46,3	53,7
Less human interaction	34,9	65,1
Dependence on technology	28,9	71,1
Dequalification of the dentist	38,9	60,1
Loss of free judgment	40,9	59,1
Failure to respect medical confidentiality	43,6	56,4
TOTAL	40,11%	77,78%

intelligence, compared to students from developed countries according to the multicenter study by Bisdas in 2021 [12], but this lack of knowledge of AI seems to be universal as highlighted by Chen's systematic review in 2022 where 74.28% of doctors and medical students have knowledge gaps of AI [15].

Regarding the dental applications of artificial intelligence, the vast majority of students were not aware of them before the course and 49.54% were able to assimilate them after the course, which is in line with Ahmed's study in 2022 where only 23% of the students knew the applications of AI while the multicenter study by Bisdas in 2021 revealed that 56.6% of the respondents were aware of AI applications in dentistry [10,12]. These applications are variable and multiple and concern different dentistry fields [7,13,16]. Thus, its integration into clinical dentistry procedures allows a more accurate and efficient diagnosis of caries, oral cancers, periodontitis, cysts, temporomandibular joint disorders, lesions of the oral mucosa. Based on clinical and radiological data, artificial intelligence also assists in the clinical management of orthodontics, implantology and the design of prosthetic restorations. Finally, AI reduces the time spent in the chair and ensure quality treatment with accuracy and precision [3,17].

In this study, 77.78% of the students are confident about the use of artificial intelligence in dentistry, they consider it as a great revolution that will

improve dentistry which is in line with Eschert's study in 2022 where 85.7% of the students from nine Turkish dental schools believe that AI will lead to major advances in dentistry [9]; In the study conducted by Ahmed in 2022, 87% of the participants recommend AI and consider it essential in medicine and dentistry [10]. This positive, optimistic and enthusiastic view is shared by several studies [4,13–15,18]. This technology is not perceived as a threat to the sustainability of jobs but as an assistant and a working partner that will make the practice of dentistry and medicine in general more exciting [6,9,12,13]. The studies listed in Ahmed's 2022 systematic review describe artificial intelligence as a reliable tool that will make dental care better, smoother, faster and more economical [17].

However, the majority of the students expressed moderate to significant concerns about AI. Thus 53.7% of the respondents believe that AI will replace humans in dentistry; this result is also found in the study by Asmatahasin and by Sajjadi in 2021 where respectively 62.22% and 83.1% of dental students adhere to this theory of replacing the human by the machine [6,8]. Nevertheless, in the systematic review by Chen in 2022, opinions seem to be more mixed, with 6–78% of students in all medical specialties adhering to this theory, whereas other studies have underestimated this possibility [4,9,13,15]. In contrast to other professions, it is clear that artificial intelligence will have difficulty in replacing doctors or dentists, it can only help to increase the effectiveness and efficiency of medical-dental practices but in no way it can replace the intellect of the knowledge and skills of the clinician who is responsible for the final decision on treatment planning and execution. It can even less replace the practitioner–patient relationship based on communication, empathy and benevolence [12,19]. To date, only the expert use of artificial intelligence combined with conventional methodologies can make its essential contribution to medical and dental practice [20]. This theory of replacement may be explained by a lack of understanding of the implications and limitations of AI, hence the need to integrate it into the university curriculum [8,10,12]. This wish was expressed by 96% of the students in this study who wish to receive more in-depth training in AI applied to dentistry, but also by the majority of health professionals surveyed on the subject [1,4,6,10,15,18,21]. The integration of artificial intelligence as a pedagogical tool will revolutionize university teaching [22,23].

Currently, the scientific community is divided on artificial intelligence, some of its aspects are problematic such as ethical issues: confidentiality data

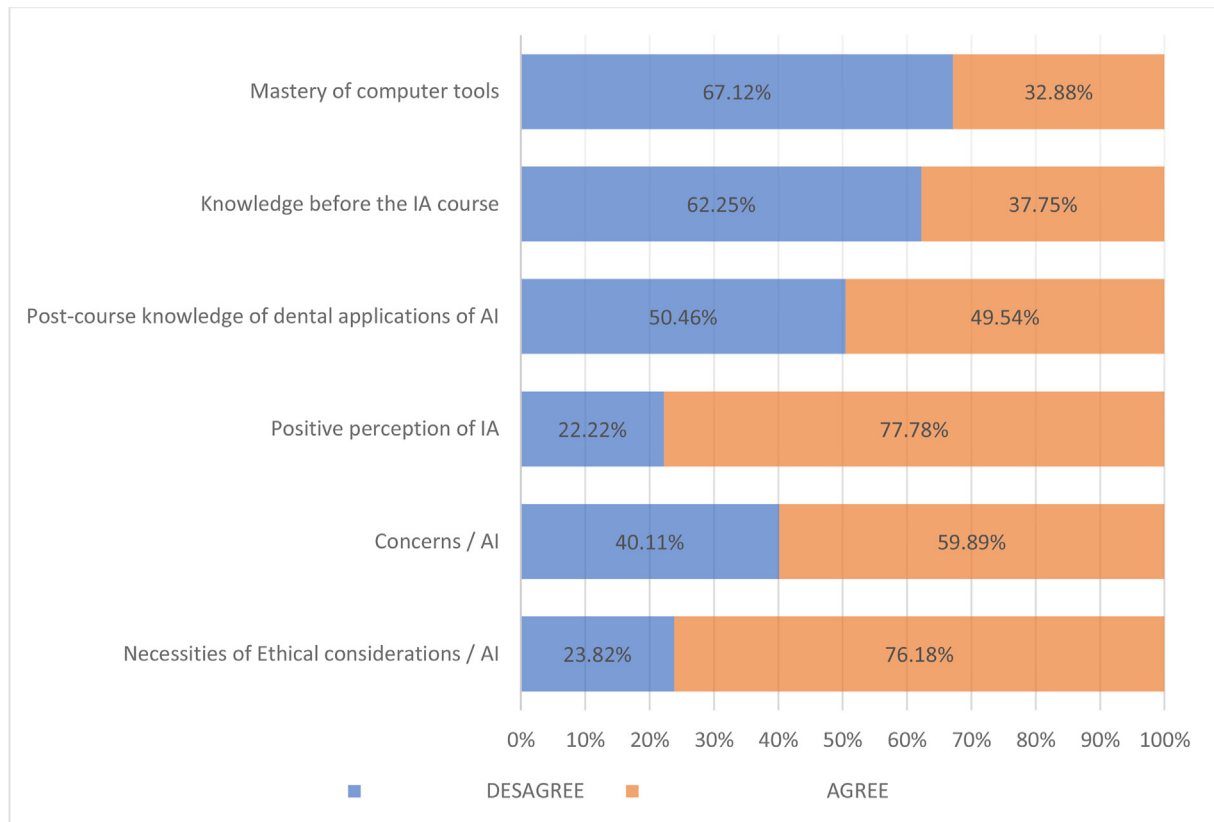


Fig. 1. Knowledge and perception of dental students.

control and security, heterogeneity of his protocols, lack of standards for clinical care, quality safety and malpractice liability in the context of AI, opacity of the algorithms used and risks of error in the presence of unusual clinical situations [2,24,26,27]. In order to maintain their autonomy and freedom of therapeutic decision, healthcare professionals must not only learn to train themselves in AI tools through initial training programs and continuous upgrades over time, but also need to be involved in the design, validation and reliability control of the algorithms governing AI [10,15,20,25,28,29].

This study presents some strong points, it is an original study carried out for the first time in Morocco and which focuses on students' perception of artificial intelligence through a wide range of closed questions, which made it possible to treat the subject in a multidimensional way.

However, self-assessment can be an unreliable indicator of students' actual knowledge, exposing our study to self-reporting bias. Nevertheless, this study can serve as a basis for future quantitative and qualitative studies on the subject and for assessing the long-term impact of the integration of artificial

intelligence into the educational curricula of dental students in Morocco.

#### 4.1. Conclusion

The development of artificial intelligence in dentistry is booming. In this study, his teaching to dental students has significantly improved their knowledge of this new technology. This survey also informed about their positive perceptions and their fears with regard to artificial intelligence. We are planning to carry out a study on the perception of students of ethics in artificial intelligence which still remains an unresolved question in this innovative field.

#### Authors' contributions

The participation of each author corresponds to the criteria of authorship and contributorship emphasized in the Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly work in Medical Journals of the International Committee of Medical Journal Editors.

Indeed, all the authors have actively participated in the redaction, the revision of the manuscript and provided approval for this final revised version.

### Conflicts of interest

The authors declare no competing interests.

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