

Knowledge, Attitude and Perception of Undergraduate Dental Students Towards Artificial Intelligence and Robotics in Dentistry

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Abstract

Background: Artificial Intelligence and Robotics in the dental field is an emerging concept worldwide, but it remains unexplored in Pakistan and there is very limited data that offers insight of dental students towards AI/R in dentistry in KCD, Peshawar.

Objective: To determine undergraduate dental students' knowledge, attitude, and perception about the implementation of Artificial Intelligence and Robotics in Dentistry.

Methodology: A Descriptive cross-sectional study was conducted using non-probability convenience sampling in undergraduate dental students from 1st to final year BDS studying in Khyber college of Dentistry, Peshawar from September 2023 to February 2024. Pre-validated questionnaires were distributed among the students. Chi square test was used for association, using R programming.

Result: Out of 134 participants included in the final analysis, a substantial proportion of respondents exhibited good knowledge (n = 92, 68.66%) and perception (n = 98, 73.13%), while a fair attitude was observed among many respondents (n = 58, 43.28%). The mean scores for knowledge, perception, and attitude were 10.40 ± 2.57 , 11.97 ± 2.45 , and 12.64 ± 4.48 , respectively. Statistically significant association was observed for knowledge (p = 0.023), whereas no significant associations were found for attitude (p = 0.105) or perception (p = 0.077). A majority of the participants, 108 (80.6%), expressed interest in learning about Artificial Intelligence and Robotics in the future.

Conclusion: Most of the participants were unaware with Artificial Intelligence and

Robotics. As it may increase the effectiveness and efficiency of dental treatment therefore there is significant need in the near future to increase awareness of this concept to maximize its benefits in Dentistry.

Introduction

Artificial Intelligence and Robotics have been used in many fields for years. With the advancements and innovations in technology, Artificial Intelligence (AI) and Robotics (R) have become a major part of our daily standard of living [1]. “Artificial Intelligence (AI) is a general term that implies the use of a computer to model intelligent behaviour with minimal human intervention. AI is generally accepted as having started with the invention of Robots” [2]. “Robotics is a branch of technology that deals with designing, construction, operation and application of Robots” [1].

Health-related fields are majorly being revolutionised by the incorporation of AI and R [3]. In Dentistry, the application of AI has been proved to yield favourable outcomes in the fields of endodontics [4] orthodontics, restorative and prosthesis [5,6] and periodontics, and its scope is increasing at a rapid rate [7,8]. Dental Robots have been proved to be able to perform endodontic work [9] and dental implantology [10]. In our daily setup, AI tools are limited to examination procedures like radiography, cone beam computed tomography (CBCT), magnetic resonance imaging (MRI), etc. [6]. However, it is possible that in future, it may be incorporated into preventive, restorative and curative dental procedures since the use and acceptance of digital methods in dentistry are evolving exponentially [7,11,12].

The dental students, graduates and senior clinicians of today need to develop the basic and necessary skills to handle advanced digital dental tools, but the curriculum contains very limited information about AI and R. The fields of Artificial Intelligence and Robotics in dentistry remained unexplored and there was very limited data that provided assessment of the knowledge, attitude and perception of dental students towards AI/R in dentistry at KCD, Peshawar. Thus, there remained a need to evaluate the topic through academic research.

This research study was inspired by a similar study carried out amongst dental students, dental graduates and senior clinicians in Saudi Arabia [1]. Similar studies were also carried out in Peru India and Turkey [13-15]. This study assessed the knowledge, attitude and perception of dental students in KCD, Peshawar and developed a sense of familiarity about the concept of AI/R among dental students, updated their knowledge and sparked their interest in this respective field, as AI is believed to have a profound future impact on dental practice [2,7]. The objective of this study was to determine the knowledge of dental students about Artificial Intelligence and Robotics, to evaluate their attitude regarding its implementation into dentistry, and to assess how they perceive this revolution in dentistry.

Materials and Methods

Study Design and Setting

This observational cross-sectional study was conducted at Khyber College of Dentistry to assess the knowledge, attitude, and perception of undergraduate dental students regarding Artificial Intelligence and Robotics in dentistry.

Study Duration

The study was carried out over a period of 15 months, from September 2023 to November 2024.

Sample Size and Sampling Technique

A non-probability convenience sampling technique was used for participant recruitment. Although 150 participants were initially approached, only 134 questionnaires were completely filled and met the inclusion criteria; therefore, these were included in the final analysis.

Inclusion and Exclusion Criteria

Undergraduate dental students enrolled at Khyber College of Dentistry,

Peshawar, who were willing to participate and provided informed consent were included in the study. Students who declined participation or submitted incomplete questionnaires were excluded from the final analysis.

Data Collection Procedure

A pre-validated questionnaire adopted from a previously conducted study was utilized for data collection [1]. Participants were provided with printed hard-copy questionnaires consisting of two sections. Section 1 included demographic characteristics of the respondents, such as gender and year of study. Section 2 consisted of 25 close-ended questions further divided into three domains: seven questions related to knowledge, eight questions related to perception, and 10 questions related to attitude regarding Artificial Intelligence and Robotics in dentistry. Responses were recorded using a three-point scale: Yes, No, and I do not know/Neutral, scored as 2, 0, and 1 respectively. Question 14 was reverse scored as Yes (0), No (2), and I do not know (1). The possible cumulative score ranges were 0–14 for knowledge, 0–16 for perception, and 0–20 for attitude. The knowledge section assessed familiarity with AI/R in dentistry, differences between AI and Robotics, applications in diagnosis and treatment planning, measurement of vital signs, examination procedures, pathology, and early cancer detection. The perception section evaluated views regarding the use of AI/R in maxillofacial surgery, orthodontics, endodontics, implant placement prediction, patient information preservation, awareness enhancement, CAD/CAM facilitation, and reduction of treatment errors. The attitude section assessed participants' attitudes towards the implementation and future role of AI/R in dentistry.

Statistical Analysis

Data were analyzed using descriptive statistics, including frequencies and percentages, to summarize participant characteristics and responses. Differences among knowledge, attitude, and perception scores were evaluated using one-way Analysis of Variance (ANOVA). Cross-tabulations of gender and year of study with knowledge, attitude, and perception variables were analyzed using Pearson's Chi-square test. Statistical significance was set at $p < 0.05$. Data analysis was performed using R programming software.

Ethical Considerations

Participation in the study was entirely voluntary, and informed consent was obtained from all participants before data collection. Confidentiality and anonymity of the participants were maintained throughout the study, and the collected data were used solely for research purposes.

Results

A total of 250 undergraduate students participated in the survey, of whom 134 met the inclusion criteria and were analyzed. The majority of the respondents were in their first year of study ($n = 42, 31.34\%$), and the sample had a nearly equal distribution of males ($n = 68, 50.75\%$) and females ($n = 66, 49.25\%$). Detailed demographic characteristics are presented in Table 1. Participants' knowledge, attitude, and perception (KAP) scores were categorized into poor, fair, and good based on pre-defined criteria. A large portion of the participants demonstrated a good level of knowledge ($n = 92, 68.66\%$) and a similarly positive perception ($n = 98, 73.13\%$). However, when it came to attitude, many respondents displayed only a fair level ($n = 58, 43.28\%$). The mean scores for knowledge, perception, and attitude were 10.40 ± 2.57 , 11.97 ± 2.45 , and 12.64 ± 4.48 , respectively.

Table 1: Demographic Characteristics and Knowledge, Attitude, and Perception (KAP) Scores of Participants ($n = 134$)

Characteristics	Variable	Frequency (%) / Mean \pm SD
Gender	Male	68 (50.75%)
	Female	66 (49.25%)

Year of Study	1st Year	42 (31.34%)
	2nd Year	25 (18.66%)
	3rd Year	27 (20.15%)
	4th Year	40 (29.85%)
Knowledge	Mean Score	10.40 ± 2.57
	Poor	5 (3.73%)
	Fair	37 (27.61%)
	Good	92 (68.66%)
Perception	Mean Score	11.97 ± 2.45
	Poor	0 (0.00%)
	Fair	36 (26.87%)
	Good	98 (73.13%)
Attitude	Mean Score	12.64 ± 4.48
	Poor	13 (9.70%)
	Fair	58 (43.28%)
	Good	63 (47.01%)

Table 2 shows the association of knowledge levels with gender and year of study. Among males, 3 (60.00%) had poor knowledge, 20 (54.05%) had fair knowledge, and 45 (48.91%) had good knowledge, while among females, 2 (40.00%) had poor knowledge, 17 (45.95%) had fair knowledge, and 47 (51.09%) had good knowledge, with no statistically significant association between gender and knowledge ($p = 0.80$). Regarding year of study, 1st-year students showed 0 (0.00%) poor, 7 (18.92%) fair, and 35 (38.04%) good knowledge, while 2nd year had 2 (40.00%) poor, 9 (24.32%) fair, and 14 (15.22%) good. Similarly, 3rd year students had 3 (60.00%) poor, 10 (27.03%) fair, and 14 (15.22%) good knowledge, whereas 4th year students showed 0 (0.00%) poor, 11 (29.73%) fair, and 29 (31.52%) good knowledge, with a statistically significant association ($p = 0.016$). As shown in figure 1, the median knowledge scores increased progressively from the first to the fourth year, reflecting the improvement in understanding as students advanced through their academic years. Considerable variation in scores was observed among second and third year students, which may suggest differing levels of engagement or comprehension within these groups. The few outliers on the lower end could represent students who might benefit from additional academic guidance or support.

Table 2: Association of Knowledge Scores with Gender and Year of Study (n = 134)

Characteristics		Poor n (%) (n = 5)	Fair n (%) (n = 37)	Good n (%) (n = 92)	p-value
Gender	Male	3 (60.00%)	20 (54.05%)	45 (48.91%)	0.80*
	Female	2 (40.00%)	17 (45.95%)	47 (51.09%)	
Year of Study	1st Year	0 (0.00%)	7 (18.92%)	35 (38.04%)	0.016*
	2nd Year	2 (40.00%)	9 (24.32%)	14 (15.22%)	
	3rd Year	3 (60.00%)	10 (27.03%)	14 (15.22%)	
	4th Year	0 (0.00%)	11 (29.73%)	29 (31.52%)	
<i>Data presented as n (%). Fisher's Exact Test applied.</i>					

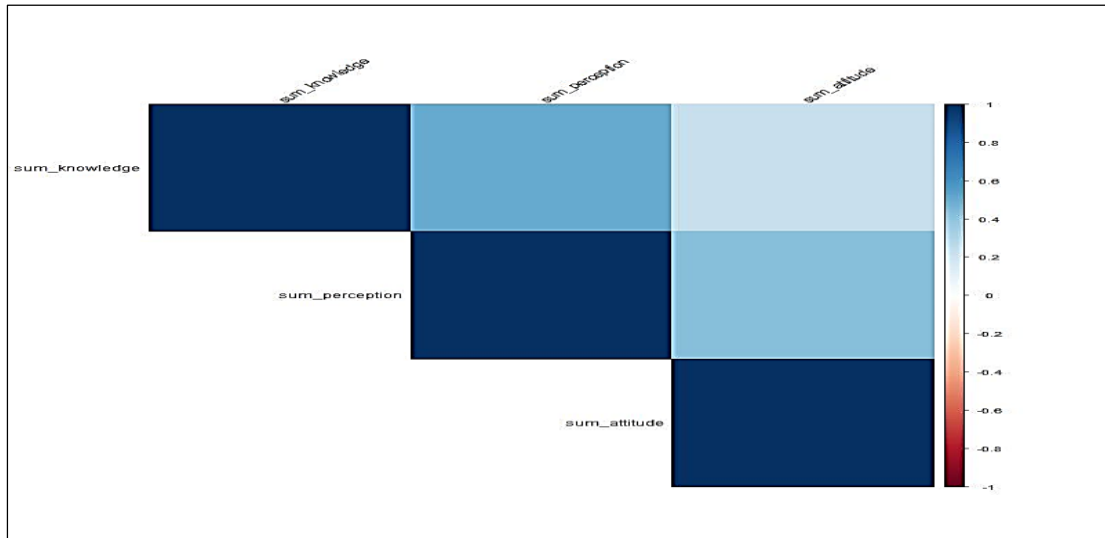


Figure 1. Box plot with jitter points showing the distribution of summed knowledge scores across different years of study

Table 3 presents the attitude distribution among participants. In males, 7 (53.85%) had poor attitude, 24 (41.38%) fair, and 37 (58.73%) good attitude, while in females, 6 (46.15%) had poor, 34 (58.62%) fair, and 26 (41.27%) good attitude, with no significant association between gender and attitude ($p = 0.20$). For year of study, 1st-year students showed 2 (15.38%) poor, 24 (41.38%) fair, and 16 (25.40%) good attitude. In 2nd year, 5 (38.46%) were poor, 9 (15.52%) fair, and 11 (17.46%) good. Third-year students had 4 (30.77%) poor, 11 (18.97%) fair, and 12 (19.05%) good, while 4th-year students showed 2 (15.38%) poor, 14 (24.14%) fair, and 24 (38.10%) good attitude, with no significant association observed ($p = 0.12$). According to figure 2, the majority of first-year students displayed fair to good attitudes, with female students showing slightly better results. As students progressed through the later years, a general shift toward more positive attitudes was noted, particularly among females. Interestingly, in the final year, a higher proportion of male students exhibited fair attitudes compared to females, suggesting that clinical exposure or academic experiences might influence the development of attitudes

Table 3: Association of Attitude Scores with Gender and Year of Study (n = 134)

Characteristics		Poor n (%) (n = 13)	Fair n (%) (n = 58)	Good n (%) (n = 63)	p-value
Gender	Male	7 (53.85%)	24 (41.38%)	37 (58.73%)	0.20†
	Female	6 (46.15%)	34 (58.62%)	26 (41.27%)	
Year of Study	1st Year	2 (15.38%)	24 (41.38%)	16 (25.40%)	0.12†
	2nd Year	5 (38.46%)	9 (15.52%)	11 (17.46%)	
	3rd Year	4 (30.77%)	11 (18.97%)	12 (19.05%)	
	4th Year	2 (15.38%)	14 (24.14%)	24 (38.10%)	
<i>Data presented as n (%).</i>					
†Pearson's Chi-square test/Fisher's Exact Test applied.					

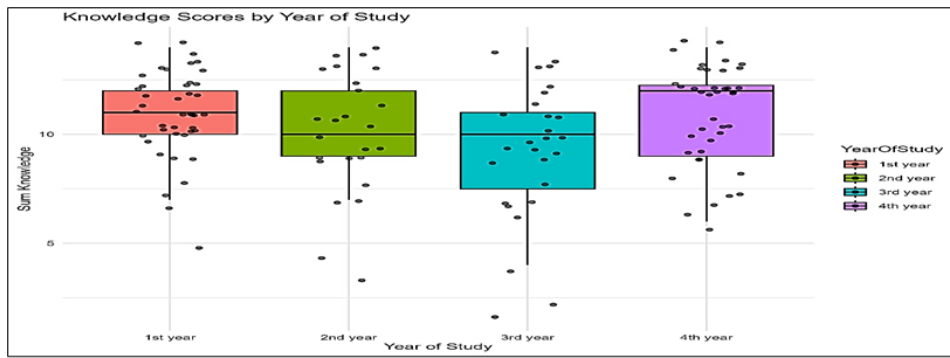


Figure 2. Distribution of attitude categories (poor, fair, and good) among male and female students across different years of study

Table 4 illustrates perception scores across gender and academic years. Among males, 16 (44.44%) had fair perception and 52 (53.06%) had good perception, while females had 20 (55.56%) fair and 46 (46.94%) good perception, with no significant association between gender and perception ($p = 0.40$). Regarding year of study, 1st-year students showed 8 (22.22%) fair and 34 (34.69%) good perception. In 2nd year, 8 (22.22%) were fair and 17 (17.35%) good, while 3rd year had 12 (33.33%) fair and 15 (15.31%) good perception. Fourth-year students showed 8 (22.22%) fair and 32 (32.65%) good perception, with no statistically significant association observed ($p = 0.086$). The correlation heatmap presented in figure 3 illustrates the relationships among the combined scores of knowledge, perception, and attitude, highlighting how these factors interact within the study population. There are strong positive correlations between all three variables, indicating that higher knowledge scores are associated with more positive perceptions and attitudes. The strongest correlation exists between perception and attitude, suggesting that students' perceptions strongly influence their attitudes. The moderate correlation between knowledge and perception implies that while knowledge has a role in shaping perceptions, other factors may also contribute.

Table 4: Association of Perception Scores with Gender and Year of Study (n = 134)

Characteristics		Fair n (%) (n = 36)	Good n (%) (n = 98)	p-value
Gender	Male	16 (44.44%)	52 (53.06%)	0.40*
	Female	20 (55.56%)	46 (46.94%)	
Year of Study	1st Year	8 (22.22%)	34 (34.69%)	0.086*
	2nd Year	8 (22.22%)	17 (17.35%)	
	3rd Year	12 (33.33%)	15 (15.31%)	
	4th Year	8 (22.22%)	32 (32.65%)	
<i>Data presented as n (%). Fisher's Exact Test applied.</i>				

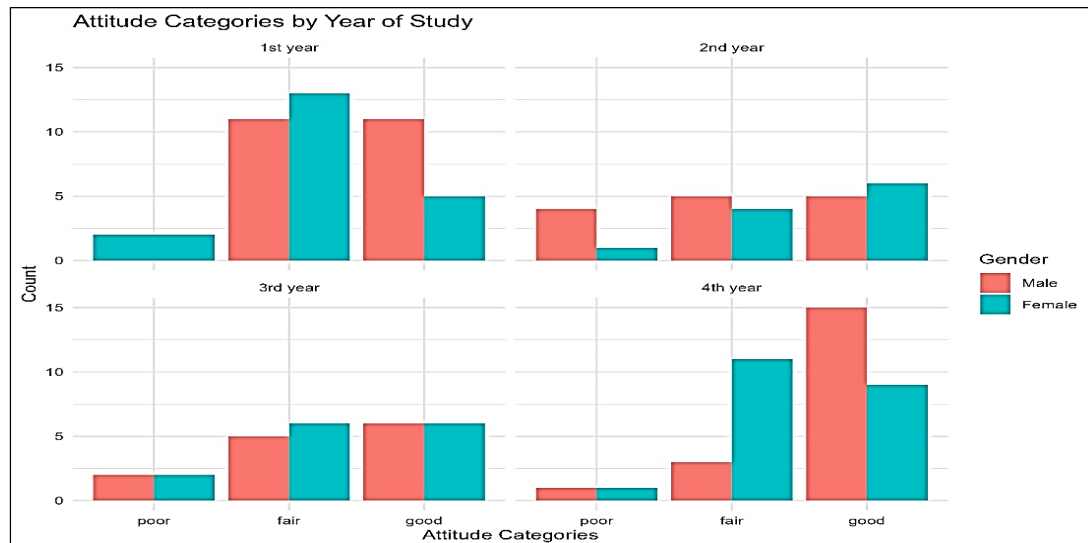


Figure 3. Correlation heatmap displaying the relationships between summed scores of knowledge, perception, and attitude

Discussion

Artificial intelligence is revolutionizing dentistry with its numerous applications [10,12,16]. Such increasing scope and demand of digitalization of dentistry require the dentists of today to have a thorough knowledge of AI/R. It is essential for the dental students to learn the basic concepts of application of AI/R in dentistry along with its implementation so they could become clinicians with updated knowledge. This study was conducted to assess the knowledge and perception and evaluate the attitude of undergraduate dental students of Khyber College of Dentistry, Peshawar. The results of the study showed that 68.7% participants had profound knowledge about AI/R in dentistry thus rejecting our null hypothesis and proving that dental students are aware of AI/R in dentistry. 64.2% participants believed that the application of AI/R could enhance their clinical practice, whereas 80.6% wanted to learn about AI/R in the future.

Although most of the students had the basic concepts about AI/R however they lacked knowledge about its implementation in dentistry when were asked Qs related to its application in the questionnaire¹. This highlights the importance for the fact that AI/R should be made part of undergraduate curriculum in Pakistan so that knowledge and training regarding it could be enhanced.

The basic curriculum of BDS provides very limited knowledge on AI/R that is merely based on few topics. The emerging scope or artificial intelligence in the fields of Endodontics, Radiology, Diagnosis and Implementation, Smile designing and Prosthodontic, and Implantology has been studied in previous researches [4,6,10,17,18,19,20]. Our study evaluated the perception of undergraduate dental students in the questionnaire (Qs 9-16) regarding its scope and 73.1% agreed with this thus showing that majority of the participants are of the view that AI/R could increase the efficiency of dental work by assisting the dentists.

Conventional dental practices could be improved by the implementation of AI/R if the dentists develop a positive attitude towards it. Our study showed that only 47.0% undergraduate dental students had a good attitude in this regard, which signals for a need for better understanding of the concept of this technology.

Like any other technology, artificial intelligence and robotics is also associated with risks and challenges but could be controlled if the practitioner develops a thorough understanding. In this era of digitalization, it is crucial for the undergraduate dental students to update their knowledge so that they are not left behind in the race towards development and breakthroughs.

Strengths and Limitations

This study is among the few local investigations assessing the knowledge, attitude, and perception of undergraduate dental students regarding Artificial Intelligence and Robotics in dentistry in Pakistan. It provides valuable baseline data from a representative academic setting at Khyber College of Dentistry, highlighting students' awareness and readiness toward emerging digital technologies in dentistry. The use of a pre-validated questionnaire enhances the reliability and comparability of findings with previously published international studies. Additionally, the study employed appropriate statistical methods, including Chi-square testing and ANOVA, to explore associations between demographic variables and KAP domains, strengthening the validity of the results. Despite its strengths, the study has certain limitations. The use of a non-probability convenience sampling technique may introduce selection bias and limit the generalizability of the findings to other institutions. Being a cross-sectional study, it captures perceptions at a single point in time and does not allow assessment of changes in knowledge or attitudes over time. The reliance on self-reported data may also introduce response bias, as participants may overestimate or underestimate their actual understanding. Furthermore, the study was conducted in a single institution, which may limit external validity across different dental colleges in Pakistan.

Conclusion

The results indicate that students generally possess good knowledge and perception of the subject, while their attitudes remain moderate, indicating a need for further improvement. The strong correlation between perception and attitude suggests that enhancing students' perceptions may help cultivate more positive attitudes. Strengthening knowledge among lower-performing students, coupled with targeted strategies to increase engagement during the middle academic years, could help reduce variability in performance.

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AI declaration: AI-assisted tools were employed in the drafting and editing of portions of this manuscript, keeping it in accordance with JRCDC policy. The authors declare that they critically approved all outputs and take full responsibility for the integrity of submitted work.

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