ORIGINAL ARTICLE

# Artificial Intelligence Literacy Among Undergraduate Dental Students: A Cross-Sectional Study from a Single Academic Institute in Lahore

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## ABSTRACT

**Objective:** To assess AI literacy among undergraduate dental students using the domains of the Meta AI literacy scale. Also, the use of ethical consideration regarding AI, AI persuasion literacy and emotional regulation.

**Study Design:** A cross-sectional study**.**

**Place and Duration of Study:** The study was conducted at the Fatima Memorial Medical and Dental College, Lahore, Pakistan, from May 2025 to June 2025.

**Methods:** Undergraduate students from all academic years were included using convenience sampling. The Meta AI Literacy Scale (MAILS), which consists of seven domains, was used to evaluate AI literacy. The Shapiro-Wilk test was used to assess the normality of the composite scores. To assess the group differences across the demographics, the One-Way ANOVA and Kruskal–Wallis Test were used. Mann-Whitney U tests and independent t-tests were conducted to compare differences between genders.

**Results:** A total of 160 undergraduate dental students (mean age 20.48 ± 1.90 years; 62.5% female) participated in the study. AI literacy varied across the seven MAILS domains, with higher scores in Use and Apply AI (mean: 5.39–6.55), Ethical considerations regarding AI (mean: 5.40–5.98), and AI persuasion literacy (mean: 5.94–6.30). On the other hand, the Create AI domain demonstrated the lowest score (mean 2.66–3.22). Students with increased self-rated computer skills were highly efficient in understanding AI, detecting AI, AI self-efficacy, and the practical use of AI ($P < 0.05$). The academic year was associated with the AI persuasion and Create AI domains ($\chi^2 = 8.50$, $P = 0.037$), whereas no significant gender differences were identified. Correlational analysis showed a positive association between understanding AI and use and application of AI ($r = 0.79$).

**Conclusion:** Although foundational AI literacy domains were generally well developed, students demonstrated notably lower scores in advanced domains, particularly AI creation.


**Keywords**: *Artificial Intelligence, Cross-Sectional Studies, Dental Education, Educational Measurement, Health Literacy.*

***How to cite this:*** *Gul M, Amin M. Artificial Intelligence Literacy Among Undergraduate Dental Students: A Cross-Sectional Study from a Single Academic Institute in Lahore. Life and Science. 2026; 7(3): 388-395. doi: http://doi.org/10.37185/LnS.1.1.955*



## Introduction

Artificial intelligence (AI) is rapidly impacting on the clinical and academic landscape of medical and dental education. This increasing incorporation of AI applications and tools for administrative tasks and diagnostic assistance highlights the importance of the upcoming healthcare professionals developing AI competencies for their future clinical practice. Machine learning-based AI tools have had a particularly strong impact in fields such as radiology, pathology, and patient monitoring. The growing use of these tools in healthcare signifies that AI has become an established reality, not just an emerging, futuristic technology. Therefore, it is vital that the next generation of healthcare professionals and clinicians are fully prepared to understand, assess,

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*Received: Jun 12, 2025; 1st Revision Received: Nov 23, 2025*
*2nd Revision Received: Apr 09, 2026; Accepted: May 03, 2026*

and use this technology effectively.[1]

AI has great potential in dentistry, with applications such as patient system management, caries detection and diagnosis, radiographic assessment, and treatment strategy. Hence, it is crucial to incorporate AI competencies into the undergraduate dentistry curriculum. Although the applications of AI platforms in clinical contexts have gained massive attention, the undergraduate dental education still remains poorly prepared for this major technological change. Recent studies show that healthcare students still have very minimal technical AI expertise, even though they regularly engage with AI tools in various clinical and academic contexts.[2]

This background stresses how crucial AI literacy is to the current healthcare education, which can be understood as 'a set of competencies that enables individuals to critically evaluate AI technologies, communicate and collaborate effectively with AI, and use AI as a tool online, at home, and in the workplace'.[3] AI literacy, just like digital literacy is quickly becoming a vital skill for future healthcare professionals.[4] Yet, few investigations have focused on dental students' actual comprehension of AI or their applied AI skills, with most studies focusing on their attitudes. Hence, there is a considerable gap in determining their actual AI competence.[5]

Despite the growing use of AI in everyday tasks, healthcare students continue to self-report limited knowledge of AI concepts.[2] Students reported mostly depending on media exposure instead of attaining any formal education or courses to learn about artificial intelligence (AI), a pattern that is repeatedly recorded across various fields and geographical regions. Gender differences in AI self-efficacy add a complex dimension to this phenomenon. Female students tend to rate their AI literacy much lower, even when they have the same level of education as their male counterparts.[1,2]

Also, these findings highlight critical gaps in dental AI education: an overreliance on informal learning, persistent self-efficacy gaps, and a lack of domain-specific competency data on dental students. Hence, the purpose of this investigation was to assess AI literacy across different domains among undergraduate dentistry students at a single Pakistani dental college. The Meta AI Literacy Scale (MAILS) was employed, a validated instrument that covers both the foundational and advanced AI competency areas.

## Methods

This was a descriptive, cross-sectional study that was conducted at the Fatima Memorial Medical and Dental College, Lahore, Pakistan, from May 2025 to June 2025. Ethical approval was obtained from the Institutional Review Board (IRB) of the institute, vide letter no. 28/03/2025-IRB-1639, dated 05th May 2025. The study observed the principles of the Declaration of Helsinki. Electronic informed consent was obtained from all participants, and participation was entirely voluntary and anonymous. The target demographic consisted of the undergraduate students enrolled in the Bachelor of Dental Surgery (BDS) program (Years 1-4). Participants were recruited through the college's official academic social media platforms. The total registered undergraduate BDS student population at the institution was approximately 300 students. The sample size of 289 students was calculated using a 95% confidence level, a 75% distribution, and a 5% margin of error, based on the sample size formula for proportions.[5] A total of 160 students completed the survey, yielding a response rate of 55.4%. As this was a cross-sectional study, there was no follow-up period involved. Data was collected at a single point in time. Our inclusion criteria were all undergraduate dental students enrolled in the BDS program at Fatima Memorial Medical and Dental College, from first to final year, who provided electronic informed consent. The exclusion criteria were MBBS students enrolled at the same institution and Dental students who did not provide informed consent.

AI literacy was assessed using the Meta AI Literacy Scale (MAILS), a validated instrument developed by Carolus A et al. The instrument contains three overarching constructs (AI Literacy, AI Self-Efficacy, and AI Self-Competency), operationalized through seven subdomains: Use and Apply AI, Understand AI, Detect AI, Ethical Considerations Regarding AI, Create AI, AI Self-Efficacy, and AI Persuasion Literacy and Emotional Regulation. It measures understanding, application, detection, ethical considerations, and conceptual engagement with AI.[6] The questionnaire comprises 34 items distributed across seven domains mentioned above. Each item is scored on an 11-point Likert scale

ranging from 0 ('no ability') to 10 ('very high ability'). The questionnaire was digitized and disseminated via Google Forms. A link to the survey was distributed. The form began with an introductory section explaining the study objectives, ethical considerations, and consent. Demographic data, including age, gender, and academic year, were also collected. No personally identifiable data was recorded to maintain anonymity. Completing the form took approximately 10-20 minutes. Non-respondents received periodic reminders to complete the survey

All data were transferred to IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA) for analysis. Descriptive statistics (mean ± standard deviation) for continuous data, and frequencies and percentages for categorical data) were employed. Normality was assessed using the Shapiro-Wilk test. Understanding AI, Detect AI, and AI self-efficacy were normally distributed, while all remaining domains did not meet the assumption of normality. The one-way ANOVA test was applied to the normal domains. Kruskal–Wallis test was applied on the non-normal domains. A significance level of $P < 0.05$ was used for all inferential analyses.

## Results

A total of 160 undergraduate dental students from Fatima Memorial Dental College, Lahore, participated in this study. The demographics show that the average age of students was 20 years, and that most were female (62.5%). Findings show that the first-year BDS had the highest response rate (30.0%). A substantial proportion of students reported no formal AI training

(58.8%) and had intermediate computer skills (52.5%) (Table 1).

**Table 1: Socio-demographic and background characteristics of participants**

| Characteristic | Frequency | Percentage (%) |
|---|---|---|
| Age, years, M ± SD (Mean ± Standard) Deviation | 20.48 ± 1.90 | range 17–25 |
| Gender — Female | 100 | 62.5 |
| Gender — Male | 60 | 37.5 |
| Academic Year — 1st Year BDS | 48 | 30.0 |
| Academic Year — 2nd Year BDS | 39 | 24.4 |
| Academic Year — 3rd Year BDS | 37 | 23.1 |
| Academic Year — Final Year BDS | 36 | 22.5 |
| Prior Formal AI Training — No | 94 | 58.8 |
| Prior Formal AI Training — Yes | 52 | 32.5 |
| Prior Formal AI Training — Maybe/Unsure | 14 | 8.8 |
| Self-Rated Computer Skills — Beginner | 67 | 41.9 |
| Self-Rated Computer Skills — Intermediate | 84 | 52.5 |
| Self-Rated Computer Skills — Advanced | 9 | 5.6 |

Figure 1 shows the mean AI literacy domain scores according to academic year. Higher scores were observed in the Use and Apply AI and AI Persuasion Literacy domains across most academic years, indicating that students can easily understand and use the existing AI technologies. The Create AI domain consistently showed the lowest scores, indicating that respondents feel less confident in developing AI applications. Variations in domain scores across academic years suggest that AI literacy competencies may improve with academic progression.

To assess the distribution of the composite AI literacy

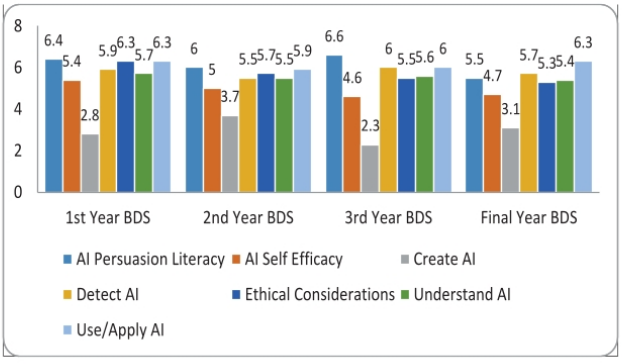


**Fig.1: Comparison of AI literacy domain scores among undergraduate dental students by academic year. Mean domain scores (0–10) by year; bars are dodged by the domain**

domain score, the Shapiro-Wilk test was applied. The table shows that the Understanding AI, Detect AI, and AI self-efficacy have a *P*>0.05, indicating a normal distribution. All other domains have a non-normal distribution (*P*<0.05). This led to the statistical test for group comparison (Table 2).

**Table 2: Shapiro–Wilk Test of Normality for Composite AI Literacy Domain Scores**

| Domain | Shapiro–Wilk Test-value | *P*- value |
|---|---|---|
| Use and Apply AI | 0.983 | .041 |
| Understand AI | 0.989 | .280 |
| Detect AI | 0.986 | .098 |
| Ethical Considerations Regarding AI | 0.973 | .004 |
| Create AI | 0.840 | <.001 |
| AI Self-Efficacy | 0.988 | .181 |
| AI Persuasion Literacy | 0.981 | .030 |

*Normality was assessed using the Shapiro–Wilk test. P > 0.05 indicates a normal distribution, whereas P ≤ 0.05 indicates a non-normal distribution*

**Table 3: Comparison of AI Literacy Domains by Demographic Group**

| Domain | Grouping Variable | df *(between, within) | **F-statistic | *P*- value |
|---|---|---|---|---|
| Understand AI | Academic Year | 3, 156 | 0.16 | .922 |
| | Prior AI Training | 2, 157 | 0.65 | .525 |
| | Self-Rated Computer Skills | 2, 157 | 11.12 | <.001 |
| Detect AI | Academic Year | 3, 156 | 0.51 | .674 |
| | Prior AI Training | 2, 157 | 0.76 | .468 |
| | Self-Rated Computer Skills | 2, 157 | 7.64 | .001 |
| AI Self-Efficacy | Academic Year | 3, 156 | 1.22 | .303 |
| | Prior AI Training | 2, 157 | 2.10 | .126 |
| | Self-Rated Computer Skills | 2, 157 | 7.56 | .001 |

**Degree of freedom, **the test statistic used in Analysis of Variance (ANOVA)*

To compare the distributions of the normally distributed variables, a one-way ANOVA was used. Post hoc analyses indicated that students with intermediate and advanced computer skills achieved significantly higher scores than beginners (all *P* < .001), whereas no significant differences were observed in groups with formal AI training. No statistically significant differences were identified across the remaining demographic variables (Table 3).The

The Kruskal-Wallis test (Table 4) was applied to the non-normal domains. Significant differences in the 'Use and Apply' and 'Ethical Considerations Regarding AI' domains were observed in the computer-level skill, with *P*-values of 0.001 and 0.026, respectively. The post hoc comparison showed progressively higher scores for the group with AI expertise at beginner or intermediate level. The academic year was linked with 'creating AI'(*P*-value = 0.037) and AI Persuasion Literacy (*P*-value = .021). Analysis shows that the Create AI domain progresses from junior to senior academic years, while in AI persuasion literacy, students score higher in the final year than in the third year.

To examine gender differences across domains, the independent t-test for normally distributed domains and the Mann-Whitney test for non-normally distributed domains) were performed, yielding results consistent with those for demographic group differences. All *P*- values were >0.05 in Understand AI, Detect AI, and AI self-efficacy. An independent-samples *t*-test showed no statistically significant differences between female and male participants in Understand AI ($t = -0.13$, $df = 118.28$, $P = .894$), Detect AI ($t = 0.31$, $df = 122.54$, $P = .754$), or AI Self-Efficacy ($t = 1.12$, $df = 115.35$, $P = .265$).

The Mann–Whitney U test revealed no statistically significant differences between female and male participants in the domains of Use and Apply AI (U = 3145.0, *P* = .610), Ethical Considerations Regarding AI (U = 3446.0, *P* = .116), Create AI (U = 3050.5, *P* = .858), or AI Persuasion Literacy (U = 3308.0, *P* = .278). The

**Table 4: Group Comparison for Non-Normally Distributed AI Literacy Domains by Demographic Group**

| Domain | Grouping Variable | $\chi^{2*}$ | Df** | *P*-value |
|---|---|---|---|---|
| Use and Apply AI | Academic Year | 1.82 | 3 | .611 |
| | Prior AI Training | 0.77 | 2 | .682 |
| | Self-Rated Computer Skills | 26.59 | 2 | <.001 |
| Ethical Considerations Regarding AI | Academic Year | 5.40 | 3 | .145 |
| | Prior AI Training | 2.76 | 2 | .251 |
| | Self-Rated Computer Skills | 7.32 | 2 | .026 |
| Create AI | Academic Year | 8.50 | 3 | .037 |
| | Prior AI Training | 1.86 | 2 | .396 |
| | Self-Rated Computer Skills | 0.57 | 2 | .754 |
| AI Persuasion Literacy | Academic Year | 9.75 | 3 | .021 |
| | Prior AI Training | 1.86 | 2 | .394 |
| | Self-Rated Computer Skills | 2.47 | 2 | .290 |

**Chi-Square test, **Degree of freedom*

**Table 5 Pearson Correlation Matrix for AI Literacy Domains**

| Variable | Apply AI* | Understand AI | Detect AI | Ethical considerations regarding AI | Create AI | AI Self-efficacy | AI persuasion literacy |
|---|---|---|---|---|---|---|---|
| Use Apply AI | 1.00 | 0.79 | 0.66 | 0.66 | 0.14 | 0.63 | 0.51 |
| Understand AI | 0.79 | 1.00 | 0.77 | 0.68 | 0.32 | 0.72 | 0.52 |
| Detect AI | 0.66 | 0.77 | 1.00 | 0.77 | 0.32 | 0.71 | 0.52 |
| Ethical considerations regarding AI | 0.66 | 0.68 | 0.77 | 1.00 | 0.30 | 0.64 | 0.55 |
| Create AI | 0.14 | 0.32 | 0.32 | 0.30 | 1.00 | 0.56 | 0.06 |
| AI Self-efficacy | 0.63 | 0.72 | 0.71 | 0.64 | 0.56 | 1.00 | 0.48 |
| AI persuasion literacy | 0.51 | 0.52 | 0.52 | 0.55 | 0.06 | 0.48 | 1.00 |

**Artificial intelligence*

Pearson Correlation matrix shows the relationships among various AI literacy domains, as shown in Table 5.

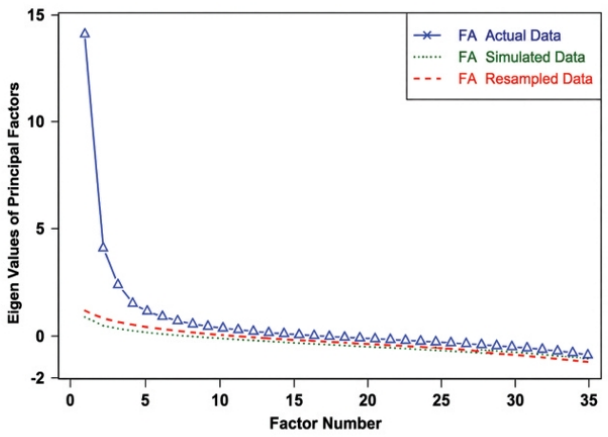


**Fig.2: Screen plot with parallel analysis**

A strong linkage was found between the 'Use and Apply AI' and 'Understand AI' ($r$ = 0.79), suggesting that conceptual understanding of AI enables the student to practically use the AI more confidently. A moderate correlation (r = 0.77) was found among the 'understand AI', 'Detect AI', and 'Ethical considerations of AI', which shows that understanding AI makes detecting AI content easier, as well as its ethical use. On the other hand, the 'Create AI' demonstrated a weaker relationship with 'Use and Apply AI' ($r$ = 0.14) and AI Persuasion Literacy ($r$ = 0.06), indicating that creating AI requires a targeted educational approach.

Exploratory factor analysis showed that the AI literacy domains clustered into three broader underlying factors (Figure 2), reflecting the interrelationships among competencies related to

understanding and using AI, self-efficacy, and higher-order engagement with AI. The findings suggest that, although the MAILS domains assess distinct aspects of AI literacy, several domains share common underlying dimensions.

## Discussion

Artificial intelligence has increasingly transformed the landscape of higher education and professional practice, which makes AI literacy a vital competency for future graduates across disciplines. This study used the Meta AI Literacy Scale (MAILS) by Carolus A et al. among undergraduate dental students.[6] The findings provide a portrait of the strengths and weaknesses in AI literacy. Impact of demographic variables and the interrelationships among the AI literacy domains. These insights can have implications for curriculum design, teaching strategies, and future AI education.[3,7]

It distinguished the foundational and advanced AI literacy domains. Understanding AI, Detect AI, and AI self-efficacy suggested that students have relatively even development of Basic AI knowledge and confidence. This shows an alignment with the other studies, which showed that due to widespread exposure to AI, there is a general understanding and detection of AI.[8,9]

The students are aware of AI's influence on their emotions and can control it. It is closely related to their personal value, which directly affects their prolonged and sustainable use of AI.[6]

They feel more confident using AI applications because they are available free of cost. They can use the AI to do their daily tasks and achieve their goals. They can easily collaborate with AI and communicate with it. Providing students with an environment where they can use AI to meet their needs can improve the quality of higher education.[10] They can evaluate the pros and cons of AI usage and its future implications. From an academic perspective, students in higher education can develop enhanced skills and competencies but can also experience psychological effects and data security issues.[11]

Most students keep pace with the rapidly changing field of AI. They can do the difficult task with AI without any external help. To further improve students' self-efficacy, the educator can set clear goals for the learning activity. Then prompt the students to use the AI to clear their concepts and give timely feedback.[12]

The remaining domains indicated a more polarized skill level, i.e., students had various levels. In the literature, it is repeatedly discussed that higher-order AI skills, such as ethical considerations, creative development, and engagement with AI content, require specific educational interventions.[7,13]

Although students demonstrated awareness of ethical considerations related to AI, scores in this domain were lower than those observed for AI utilization. This may reflect limited formal instruction regarding topics such as algorithmic bias, transparency, accountability, patient privacy, and informed consent. Given the increasing use of AI in clinical decision-making, ethical literacy should be considered a core component of future dental education rather than an optional topic.[14] Students need formal education on the ethical aspects of AI. Educators need to ensure that AI ethics, including the concept of informed consent, are integrated into the current curriculum before students use AI applications.[14] The students faced the most difficulty in creating a new AI program. The significantly low score in the 'Create AI' domain reflects the nature of undergraduate dental education, as the focus is more on using digital technologies than on developing new ones. Most students have exposure to AI through educational or clinical applications, but they are given no knowledge of programming, prompt engineering, or algorithm design. This led to the weak linkage between the AI usage skills and AI creation competencies.[15,16]

Demographics significantly influence the AI literacy domains. Dental students' academic year and prior AI exposure strongly influence the Understand AI, Detect AI, and AI self-efficacy domains.[7,17] It shows that AI literacy is not static; it requires well-structured, progressive learning experiences.[3] Rest of the domains show variations among students, which indicate the integration of AI across all the academic years.[18]

There was no significant difference in AI literacy between the two genders. However, a minor level of variation was still there in specific contexts like the advanced AI domain. In a review by Shah SS et al., gender bias can arise from bias in training data and the choice of algorithm design.[19]

This indicates that increasing the availability of AI platforms to contemporary students might help achieve more comparable levels of technology exposure across genders.[2]

The relationship across domains suggests that students' understanding of AI and their confidence in engaging with AI technologies are strongly interdependent. Students who better understand the capabilities and limitations of AI may feel more comfortable integrating such tools into academic and clinical activities. This finding supports educational approaches that prioritize foundational AI concepts before introducing advanced applications.[12]

Also, students who understand AI-related ethical issues are more likely to demonstrate creativity with AI. It is emphasized that there should be an 'explainable AI' that can help in a better understanding of AI concepts and make it more accessible.[20,21]

For foundational domains, i.e., understanding AI, detecting AI, and AI self-efficacy, are strongly influenced by the academic year and prior exposure to AI of dental students. In a study that used MAILS to assess the academic performance of tertiary-level students, researchers found a weak association between academic performance and AI use.[22]

In contrast to the more advanced domains, the underscored role of the educational background and the extracurricular engagement in fostering practical, ethical, and creative AI skills.[7,23]

AI courses can be designed for students of any background and gender. This will reduce the gender division in the AI field and also the generalizability of AI among students.[24] Students with better AI literacy can incorporate AI in their future academic and clinical tasks. As AI applications become increasingly integrated into radiographic interpretation, caries detection, orthodontic planning, and clinical decision support, inadequate AI literacy may hinder future dentists' ability to critically evaluate AI-generated outputs. Developing AI literacy during undergraduate training may therefore promote safer and more effective adoption of AI technologies in clinical practice.[15,25]

In addition to valuable insights, this study has some limitations. The study was conducted at a single institution, and sampling was done using a convenience sampling method; therefore, the generalizability of the findings cannot be ensured. Moreover, the higher level of female students as respondents may have influenced the results. There was an increased participation bias because the survey was administered via Google Forms; therefore, students who were more digitally engaged benefited. Future research recommendations include multicenter studies along with more diverse samples. Both will enhance the generalizability of these results.

## Conclusion

Undergraduate dental students have strong competencies in understanding, using, and applying AI. In comparison, they showed a lower level of skill in creating and developing AI. The academic year influences various literacy domains, while the gender differences have no significant effect. Integrating AI educational activities into dental curricula can enhance preparedness for future AI-enabled clinical practice.

**Acknowledgment**: None

**Conflict of Interest**: The authors declare no conflict of interest

**Grant Support and Financial Disclosure**: None

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**Author Contributions**

**MG:** Conception, design of the work, manuscript writing for methodology design, investigation, revising, editing, supervising for intellectual content, writing the original draft, proofreading, and approval for final submission

**MA:** Data acquisition, curation, statistical analysis, validation of data, interpretation, write-up of results and discussion, and approval for final submission

**MG is the nominated guarantor and takes full responsibility for the overall content and integrity of the work**