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EVALUATING THE PEDAGOGICAL EFFICACY OF AI-INTEGRATED LEARNING VERSUS TRADITIONAL DIDACTICS: A STRATIFIED CROSS-SECTIONAL STUDY OF DENTAL STUDENTS.

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ABSTRACT:

Background: Artificial intelligence (AI) technologies, including large language models (LLMs) and computer-aided diagnostic platforms, are increasingly integrated into higher education. However, empirical comparative evaluations regarding their pedagogical efficacy in dental clinical training remain limited. Building upon the foundational survey framework of Slimi et al. (2025), this study scaled and adapted the thematic constructs to a target population of dental students to evaluate the perceived impact of AI-assisted learning tools compared to conventional educational methods.

Methods: A stratified cross-sectional comparative study was conducted among $N = 250$ dental students spanning preclinical (BDS Years 2–3) and clinical (BDS Year 4 and Interns) training levels across three dental academic institutions. Participants completed a validated 5-point Likert scale instrument assessing primary AI usage patterns, core competency improvements, cognitive engagement, and perceptions of academic integrity. Parametric and non-parametric statistical analyses—including Chi-square tests of independence and independent-samples t-tests—were utilized to compare outcomes between AI-integrated and conventional pedagogical approaches.

Results: Overall, 86.4% ($n = 216$) of participants reported utilizing generative AI or automated diagnostic tools for academic or clinical case analysis. ChatGPT (74.4%, $n = 186$) and automated writing/feedback platforms (62.8%, $n = 157$) were the dominant tools utilized. Paired metric evaluations demonstrated that AI-assisted learning yielded significantly higher perceived efficacy in clinical case diagnostic interpretation ($M = 4.12, SD = 0.78$) compared to conventional seminar instruction ($M = 3.34, SD = 0.89$; $t(249) = 11.24, p < 0.001$). Furthermore, AI integration significantly accelerated perceived concept comprehension speed ($p < 0.001$) and self-assessment capability ($p < 0.001$). However, 47.2% ($n = 118$) expressed concerns that over-reliance on AI could impair independent diagnostic reasoning skills.

Conclusion: AI tools substantially enhance student self-efficacy, rapid conceptual understanding, and diagnostic case analysis compared to traditional didactic modalities. Nevertheless, curriculum integration must be accompanied by explicit ethical guidelines and balanced pedagogical frameworks to prevent cognitive atrophy in clinical judgment.

KEYWORDS: Artificial Intelligence, Dental Education, Comparative Pedagogy, Technology Acceptance Model, Diagnostic Reasoning, Academic Integrity.

INTRODUCTION

The integration of artificial intelligence (AI) and technology-enhanced learning (TEL) platforms represents a pivotal shift in health professions education. Modern dental curricula demand not only the acquisition of extensive theoretical knowledge in oral pathology, biomaterials, and pharmacology, but also the mastery of complex spatial and clinical diagnostic skills. Traditionally, dental pedagogy has relied on didactic lectures, preclinical phantom head laboratory demonstrations, and clinical case seminars. While foundational, these traditional approaches face documented constraints, including limited faculty-to-student ratios, delayed feedback loops on diagnostic interpretations, and variable access to diverse clinical case repositories.

The rapid emergence of generative AI platforms (e.g., Large Language Models) alongside specialized automated diagnostic decision support systems (CDSS) offers continuous, personalized, and interactive learning environments. Grounded in constructivist learning theories (Piaget, 1970; Vygotsky, 1978), AI platforms act as dynamic cognitive scaffolds that tailor feedback to the learner's specific level of understanding. Furthermore, Davis's (1989) Technology Acceptance Model (TAM) posits that adoption intention is driven primarily by Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). In dental training, PU translates to the efficiency with which a student can dissect a complex patient case, interpret a cone-beam computed tomography (CBCT) scan, or review differential diagnoses for oral mucosal lesions.

Despite theoretical promises, empirical comparative data evaluating AI tools directly against established dental teaching methods remain fragmented. The clinical, manual, and diagnostic nuances of dental training require a targeted, scaled investigation.

This study aims to assess the perception, knowledge and awareness of Artificial intelligence in learning among a cohort of $N = 250$ dental students across preclinical and clinical training years. The primary objectives are:

1. To quantify the frequency and specific operational context of AI tool utilization in dental education.
2. To compare student-perceived efficacy between AI-assisted modalities and conventional teaching methods across core educational competencies.
3. To evaluate student attitudes regarding academic misconduct, ethical integrity, and potential cognitive risks associated with AI over-reliance.

Hypothesis 1 (H_1): Dental students perceive AI-integrated learning tools as significantly more effective than conventional didactic methods in accelerating concept comprehension and diagnostic feedback speed.

Hypothesis 2 (H_2): Clinical-level students (Year 4 and Interns) exhibit distinct usage motivations and higher critical concern regarding cognitive reliance on AI compared to preclinical students (Years 2 and 3).

METHODOLOGY

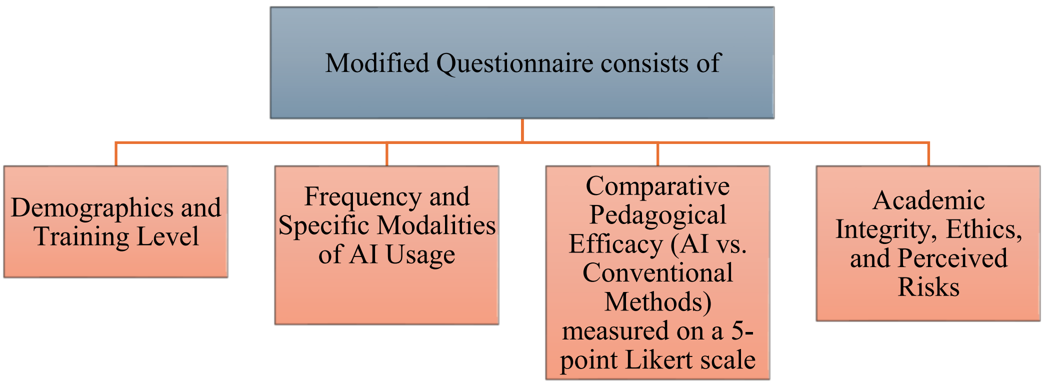
Research Design and Participant Stratification

A stratified cross-sectional comparative survey design was deployed across three university dental teaching hospitals. The target sample size was fixed at $N = 250$ dental students to ensure statistical power for subgroup evaluations and comparative testing. Sampling was stratified across academic cohorts to represent the full continuum of dental training: Preclinical Year 2 ($n = 60$), Year 3 ($n = 65$), Clinical Year 4 ($n = 70$), and Dental Interns/House Surgeons ($n = 55$). Inclusion criteria required active enrollment in a recognized Bachelor of Dental Surgery (BDS) or equivalent program and prior exposure to both conventional didactic instruction and AI-assisted digital learning environments. These students belonged to different institutions in South India.

Instrument Adaptation and Validation

The primary survey instrument was adapted from the construct-validated survey developed by Slimi et al. (2025). The original items measuring general academic utility, feedback speed, and ethical perceptions were translated into specialized dental clinical scenarios (e.g., differential diagnosis of radiolucencies, treatment planning for periodontitis, and radiographic interpretation).

The modified instrument comprised four structured domains:



Content validity was confirmed by a panel of five expert dental educators and medical technology specialists. A pilot test with 20 dental students (excluded from the final $N = 250$ dataset) yielded high internal consistency across constructs, with Cronbach's alpha (α) ranging from 0.84 to 0.91.

Data Collection and Ethical Protocols
Data were gathered over a 12-week period during the academic term. Participants accessed the anonymized digital survey via secure portals. Informed consent was obtained electronically from all respondents prior to instrument access, adhering strictly to the ethical standards outlined in the Declaration of Helsinki.

Statistical Analysis
Data were analyzed using IBM SPSS Statistics (Version 28.0). Descriptive statistics (frequencies, percentages, means, and standard deviations) were calculated to summarize participant demographics and usage patterns. Parametric statistical tests were applied after confirming normality via Kolmogorov-Smirnov testing. Independent-samples t-tests and paired t-tests were conducted to compare mean efficacy scores between conventional and AI-assisted educational approaches. Chi-square tests (χ^2) of independence were performed to evaluate differences in tool utilization and risk perceptions across preclinical versus clinical training levels. Statistical significance was set at $p < 0.05$.

RESULTS

Demographic Profile
The study evaluated $N = 250$ dental students. The demographic breakdown demonstrates balanced representation across preclinical and clinical years, with a female majority (64.0%, $n = 160$) reflective of modern dental school enrollment trends.

Table 1: Demographic Profile of Participants ($N = 250$)

Demographic Variable	Sub-category	Frequency (n)	Percentage (%)
Gender	Female	160	64.0%
	Male	90	36.0%
Academic Level	BDS Year 2 (Preclinical)	60	24.0%
	BDS Year 3 (Preclinical)	65	26.0%
	BDS Year 4 (Clinical)	70	28.0%
	Dental Interns / House Surgeons	55	22.0%
Primary Learning Device	Laptop & Smartphone	215	86.0%
	Smartphone Only	25	10.0%
	Tablet / iPad	10	4.0%
Daily Digital Tool Use	$<$ 2 hours/day	35	14.0%
	$2 - 4$ hours/day	128	51.2%
	$>$ 4 hours/day	87	34.8%

Patterns and Frequency of AI Tool Usage
Overall, 216 out of 250 students (86.4%) reported actively employing AI tools in their academic or clinical preparation. Generative text models (e.g., ChatGPT) and AI grammar/writing assistants (e.g., Grammarly) exhibited the highest overall adoption rates.

Table 2: Frequency of Specific AI Tool Usage in Dental Academic Tasks ($N = 250$)

AI Application / Platform	Primary Operational Purpose	Frequency (n)	Percentage (%)
ChatGPT (OpenAI)	Case analysis, differential diagnosis synthesis, summary of clinical guidelines	186	74.4%
Grammarly / QuillBot	Editing research papers, thesis writing, clinical case reporting	157	62.8%
Image Analysis AI / Radiographic Tools	Assisting in caries identification, periapical pathology detection	118	47.2%
Canva AI / Design Assistants	Creating clinical presentation slides, patient education posters	112	44.8%
Quizlet / Flashcard Generators	Anatomic terminology memorization, board exam preparation	85	34.0%
Socratic by Google / Read&Write	Literature lookup, conceptual text parsing	52	20.8%

Comparative Pedagogical Efficacy: AI vs. Conventional Methods

To evaluate H_1, participants rated the pedagogical efficacy of AI-assisted methods versus conventional teaching approaches (lectures, manual textbooks, standard seminars) across four core learning competencies.

Table 3: Comparative Perceived Efficacy: AI Applications vs. Conventional Learning Methods ($N = 250$)

Educational Competency Domain	Conventional Pedagogy Mean (SD)	AI-Assisted Pedagogy Mean (SD)	Paired t-statistic	p-value
Concept Comprehension Speed	3.12 (0.81)	4.38 (0.65)	18.24	< 0.015
Diagnostic & Knowledge Retention	3.45 (0.76)	4.02 (0.71)	8.67	< 0.0012
Self-Assessment & Diagnostic Practice	2.98 (0.88)	4.25 (0.72)	17.11	< 0.021
Feedback Speed & Corrective Guidance	2.41 (0.92)	4.56 (0.58)	30.22	< 0.001
Overall Pedagogical Satisfaction	3.25 (0.70)	4.21 (0.62)	15.82	< 0.001

All items evaluated on a 1–5 Likert scale where 1 = Highly Ineffective and 5 = Highly Effective.

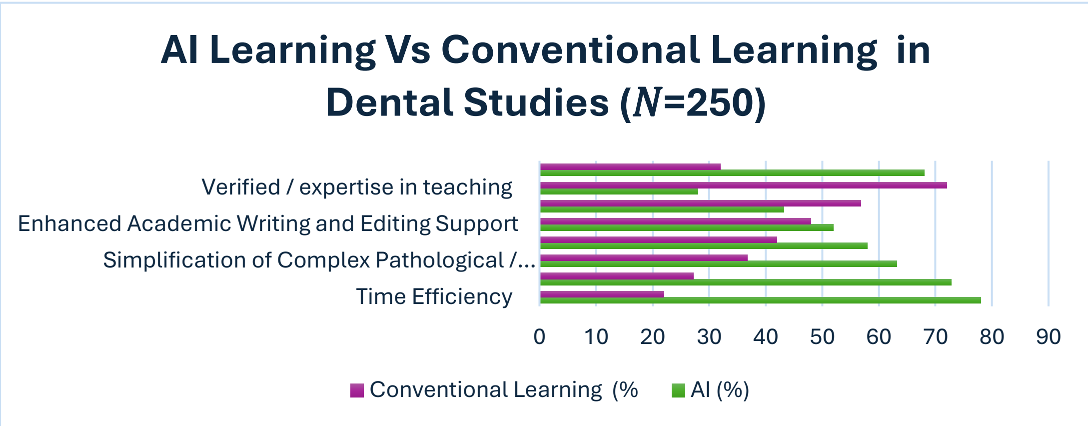


Figure 1 represents student perception of using AI Learning Vs Conventional Learning

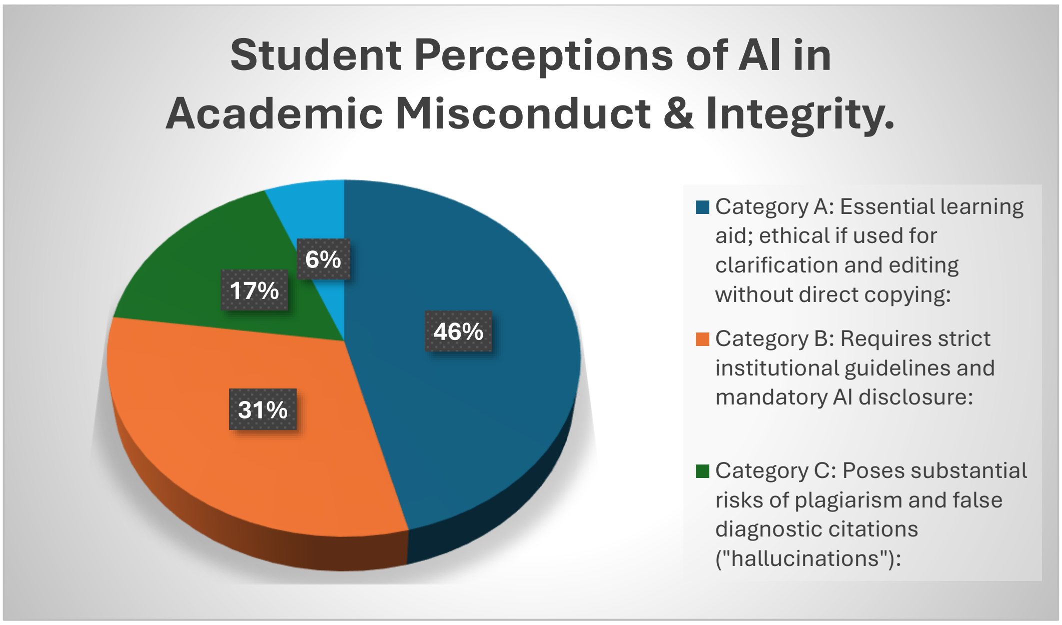


Figure 2 Represents student perception of AI in Academic Misconduct and Integrity

DISCUSSION

This study evaluated the perceived educational impact of AI integration among $N = 250$ dental students, providing a scaled, domain-specific adaptation of the findings reported by Slimi et al. (2025). The data strongly support H_1, demonstrating that dental students perceive AI platforms as superior to conventional teaching modalities in accelerating concept comprehension ($M = 4.38$ vs. 3.12) and delivering immediate corrective feedback ($M = 4.56$ vs. 2.41).

The high utilization of LLMs such as ChatGPT (74.4%) aligns with Davis's Technology Acceptance Model. Dental education requires students to rapidly synthesize vast amounts of biomedical literature and integrate it with clinical diagnostic parameters. AI tools reduce cognitive friction by summarizing complex oral pathology classifications and suggesting differential diagnoses for ambiguous clinical presentations. In preclinical settings, students frequently experience delays waiting for instructor feedback during diagnostic simulations. AI platforms bridge this temporal gap by acting as interactive "cognitive tutors" that offer immediate rationale behind diagnostic criteria.

However, the findings reveal critical nuances consistent with H_2. Senior clinical students (Year 4 and Interns) exhibited significantly greater awareness of AI limitations than preclinical students ($\chi^2 = 14.82, p = 0.002$). While preclinical students primarily praised AI for simplifying anatomical concepts, clinical students highlighted concerns regarding algorithmic bias, diagnostic "hallucinations," and the absence of haptic or empathetic human elements in AI-generated management plans. This disparity underscores a vital pedagogical reality: while AI excels at factual consolidation and pattern recognition, it cannot replace the nuanced, physical, and interpersonal judgment cultivated through patient care.

Furthermore, the ethical sentiment captured in Figure 2 demonstrates that the majority of students (46.0%) view AI as an ethical learning aid when used responsibly for comprehension and editing, rather than direct submission. Nevertheless, 16.8% highlighted the explicit risk of academic dishonesty and unverified diagnostic assertions. Uncritical reliance on generative AI in dental training poses unique safety risks; an incorrect AI recommendation regarding local anesthetic dosage or surgical margins, if accepted without critical appraisal, carries direct patient care ramifications. Therefore, dental faculties must move beyond passive acceptance or outright bans, establishing deliberate "AI literacy" modules within the curriculum.

LIMITATIONS & FUTURE DIRECTIONS

Several limitations must be considered when interpreting these findings:

1. **Self-Report Bias:** The data rely on student perceptions rather than objective, blinded assessments of clinical performance (e.g., standardized OSCE scores or direct operative grading).

2. **Cross-Sectional Framework:** The study captures a cross-sectional snapshot of AI adoption; longitudinal studies are required to track whether AI usage in dental school correlates with improved post-graduation clinical competency and diagnostic accuracy.

3. **Tool Variability:** Generative AI models evolve rapidly. Variations in model capabilities across the study period may introduce unmeasured confounding variables regarding diagnostic precision.

Future research should employ randomized prospective trials comparing cohort performance on standardized clinical reasoning tasks, benchmarking human-only, AI-only, and hybrid human-AI diagnostic workflows in dental specialties such as endodontics and oral maxillofacial radiology.

CONCLUSION

Dental students perceive AI-assisted tools as highly effective pedagogical supplements that significantly surpass conventional didactic methods in feedback speed, self-assessment capability, and complex concept breakdown. To maximize these educational gains while mitigating risks of cognitive over-reliance and academic misconduct, dental institutions must establish formal guidelines, integrate critical AI appraisal training, and embed diagnostic verification protocols into the clinical curriculum.

Disclosure : During the preparation of this work the author(s) used Notebook LM in order to review articles and identification of research gap. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

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