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INTEGRATION OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) ENABLED TOOLS IN DENTAL EDUCATION: PERCEPTIONS OF UNDERGRADUATE STUDENTS IN KERALA – A CROSS-SECTIONAL STUDY

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ABSTRACT

Introduction: Information and Communication Technology (ICT) has transformed modern education, offering powerful digital tools that enhance teaching, learning, assessment, and clinical training. In dental education, ICT promotes efficient academic management, digital simulation, self-directed learning, and improved clinical record handling. Understanding students' perceptions of such tools is essential for developing an ICT-integrated curriculum in Kerala.

Aim: To assess the perceptions of undergraduate dental students in Kerala regarding the integration of ICT-enabled tools in the dental teaching curriculum.

Methods: A validated questionnaire (Content Validity Index: 0.82) was distributed online to 400 undergraduate dental students across multiple institutions in Kerala. The survey consisted of two parts: Part A—demographics; Part B—20 items assessing perceptions of ICT usage in dental education, including learning management systems (LMS), virtual simulation, digital patient records, tele-dentistry modules, and e-assessment strategies. Responses were recorded using a 4-point Likert scale. Data were analyzed using SPSS Version 25. Descriptive statistics, Chi-square tests, and Pearson correlation were applied. $P < 0.05$ was considered significant.

Results: The majority of students agreed that ICT improves conceptual understanding (82%), enhances clinical preparedness (76%), and supports self-paced learning (88%). Significant correlations were found between year of study and preference for digital simulation ($p < 0.01$), ICT-based assessment ($p < 0.05$), and digital patient management modules ($p < 0.05$). Students expressed challenges such as device affordability (46%), inconsistent internet connectivity (58%), and lack of formal ICT training (63%). Nearly 91% agreed that ICT modules should be formally incorporated into the dental curriculum.

Conclusion: Dental students in Kerala show strong acceptance of ICT-enabled educational tools. Structured curriculum integration, faculty training, and enhancement of digital infrastructure are essential for maximizing ICT's benefits in dental education.

Keywords: Dental curriculum, ICT-enabled learning, digital dentistry education, virtual simulation, e-learning tools

INTRODUCTION

Information and Communication Technology (ICT) refers to the digital tools and resources used to communicate, create, disseminate, store, and manage information. ICT has created significant transformations in higher education, including medical and dental teaching[1]. Globally, ICT improves accessibility of learning materials, encourages interactive learning, and supports evidence-based practice[1,2]. The integration of digital technology has become a transformative force across various educational domains, with dental education standing as a prominent beneficiary[3]. The traditional model of dental training, while foundational, is increasingly being augmented by digital tools that offer innovative methods to enhance

both learning and clinical preparedness. These technologies provide significant opportunities to strengthen preclinical skill acquisition, streamline clinical documentation, enhance patient communication, and track academic progress with greater efficiency[4].

The landscape of digital dental education is diverse and rapidly evolving. Key tools facilitating this transformation include virtual simulation and haptic devices, which allow for the practice of manual skills in a risk-free environment[5], and digital radiography alongside CAD/CAM learning modules, which introduce students to the standard technologies of modern restorative dentistry. Furthermore, institutional operations are supported by Learning Management Systems (LMS) such as Moodle, Canvas, and Google Classroom, which centralize academic content and administration[2].Beyond the classroom and simulation lab, digital tools extend into clinical and patient management realms. Tele-dentistry platforms[6] and AI-based patient record systems are revolutionizing patient interactions and data handling, while mobile-health (mHealth) applications provide point-of-care information and facilitate patient education. Pedagogically, online case-based learning fosters critical thinking, and e-assessment platforms offer efficient and scalable methods for evaluating student performance[7].Given this rapid digital expansion, it is crucial to understand the perceptions, readiness, and integration levels of these tools among the primary learners: dental students[8]. This study aims to explore the adoption and impact of these digital technologies within undergraduate dental education, providing a snapshot of the current educational paradigm and informing future curricular developments.The Dental Council of India (DCI) and the National Education Policy (NEP 2020) advocate the incorporation of ICT into dental curricula to create digitally competent graduates prepared for modern clinical environments[9],[10]. Kerala, with its advanced digital literacy initiatives such as Kerala Fibre Optic Network (KFON) and Digital University of Kerala, provides a promising environment for ICT-enabled dental education[11]. However, there is limited evidence regarding students' perceptions and readiness to adopt ICT in dental training[8],[12].This study aims to address this gap by evaluating the perceptions of dental students in Kerala towards ICT-enabled learning tools and their integration into the dental curriculum.

MATERIALS AND METHODS

This cross-sectional online survey was designed to target undergraduate dental students enrolled in Kerala's private and government dental colleges. The minimum sample size was calculated as 385 using the standard formula (Z=1.96, P=0.5, d=0.05), which was rounded up to 400 to account for non-response. Participants were recruited via convenience sampling and were required to be BDS students from any year (1st to 5th) who were familiar with digital learning tools and provided consent. The exclusion criteria comprised house surgeons and students lacking access to a digital device. The data collection instrument was a structured online questionnaire disseminated through official college channels.

Data Collection Tool

Data were collected using a structured questionnaire consisting of demographic items and an ICT Perception Scale. The demographic section included age, gender, year of study, device ownership, and internet accessibility. The ICT Perception Scale comprised 20 items covering multiple domains related to digital learning, including e-learning readiness, use of Learning Management Systems (LMS), digital preclinical simulation, ICT-enabled clinical record-keeping, tele-dentistry training, digital radiography learning, AI-based training modules, mHealth-supported flipped-classroom models, and e-assessment tools. All items were graded using a four-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree."

Pilot Study

A pilot study was carried out among 25 students to assess the clarity, validity, and reliability of the questionnaire. The tool demonstrated high internal consistency, with a Cronbach's alpha value of 0.86. Data obtained from the pilot group were excluded from the main analysis.

Statistical Analysis

Data entry was performed using Microsoft Excel, and statistical analyses were carried out using SPSS version 25. Descriptive statistics were computed to summarize the study variables. Chi-square tests were used to assess associations between categorical variables, while Pearson correlation analysis was applied to evaluate relationships between ICT perception domains. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of 400 undergraduate dental students completed the questionnaire. The demographic distribution revealed that the majority of participants were female (68%), while male students constituted 32%. This is depicted in **Figure 1**, demonstrating a clear predominance of female respondents, consistent with typical enrolment patterns observed in Indian dental institutions.

Table 1: Demographic Characteristics of the Study Participants (N=400)

Characteristic	Category	Frequency (n)	Percentage (%)
Gender	Female	272	68.0

	Male	128	32.0
Year of Study	First Year	85	21.3
	Second Year	82	20.5
	Third Year	80	20.0
	Fourth Year	78	19.5
	Final Year	75	18.8
Device Ownership	Personal Laptop	350	87.5
	Personal Tablet	180	45.0
	Smartphone only	50	12.5
Internet Access	Stable at Home & College	250	62.5
	Unstable/Inconsistent	150	37.5

Figure 1. Gender Distribution of Study Participants

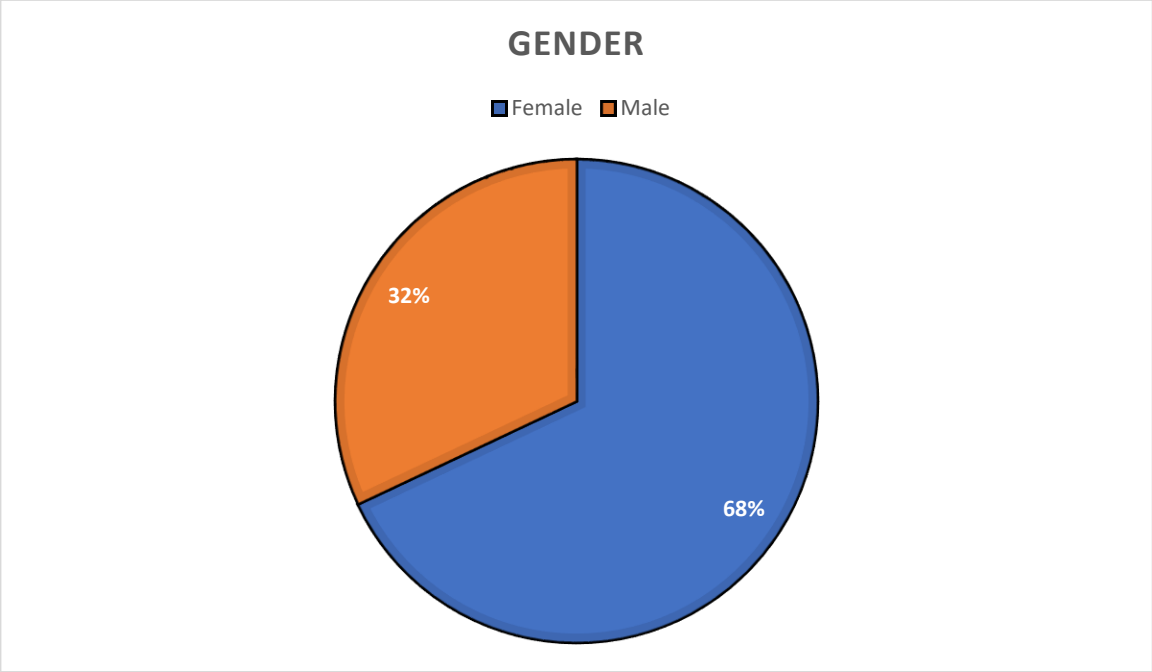


Table 2: Student Perceptions and Attitudes Towards ICT-Enabled Tools (N=400)

ICT Domain / Statement	Strongly Agree n(%)	Agree n(%)	Neutral n(%)	Disagree n(%)	Strongly Disagree n(%)
General Usefulness					
Improves conceptual understanding	164 (41.0)	164 (41.0)	56 (14.0)	12 (3.0)	4 (1.0)
Enhances clinical preparedness	144 (36.0)	160 (40.0)	72 (18.0)	20 (5.0)	4 (1.0)
Supports self-paced learning	200 (50.0)	152 (38.0)	40 (10.0)	8 (2.0)	0 (0.0)
Specific Tools					
Virtual simulation strengthens preclinical confidence	180 (45.0)	160 (40.0)	44 (11.0)	12 (3.0)	4 (1.0)
Prefer LMS over traditional lectures	140 (35.0)	172 (43.0)	64 (16.0)	20 (5.0)	4 (1.0)
Training in digital patient records is needed	152 (38.0)	172 (43.0)	60 (15.0)	12 (3.0)	4 (1.0)
Interested in tele-dentistry training	196 (49.0)	160 (40.0)	32 (8.0)	8 (2.0)	4 (1.0)
Curriculum Integration					
ICT should be formally integrated into curriculum	220 (55.0)	144 (36.0)	28 (7.0)	4 (1.0)	4 (1.0)

Figure 2. Perception of ICT Usefulness among Dental Students

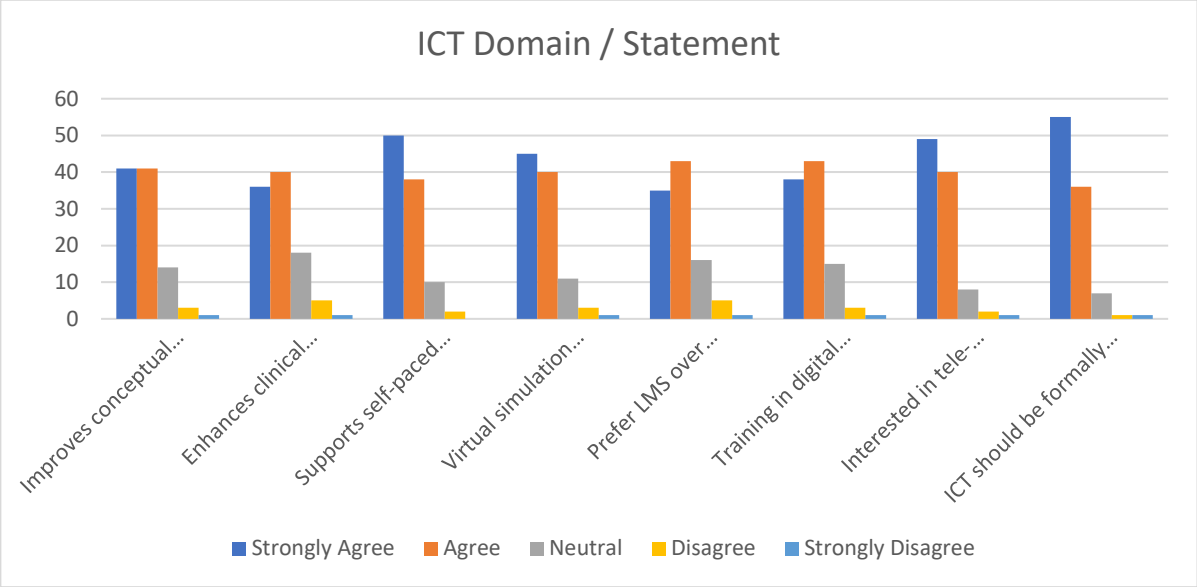


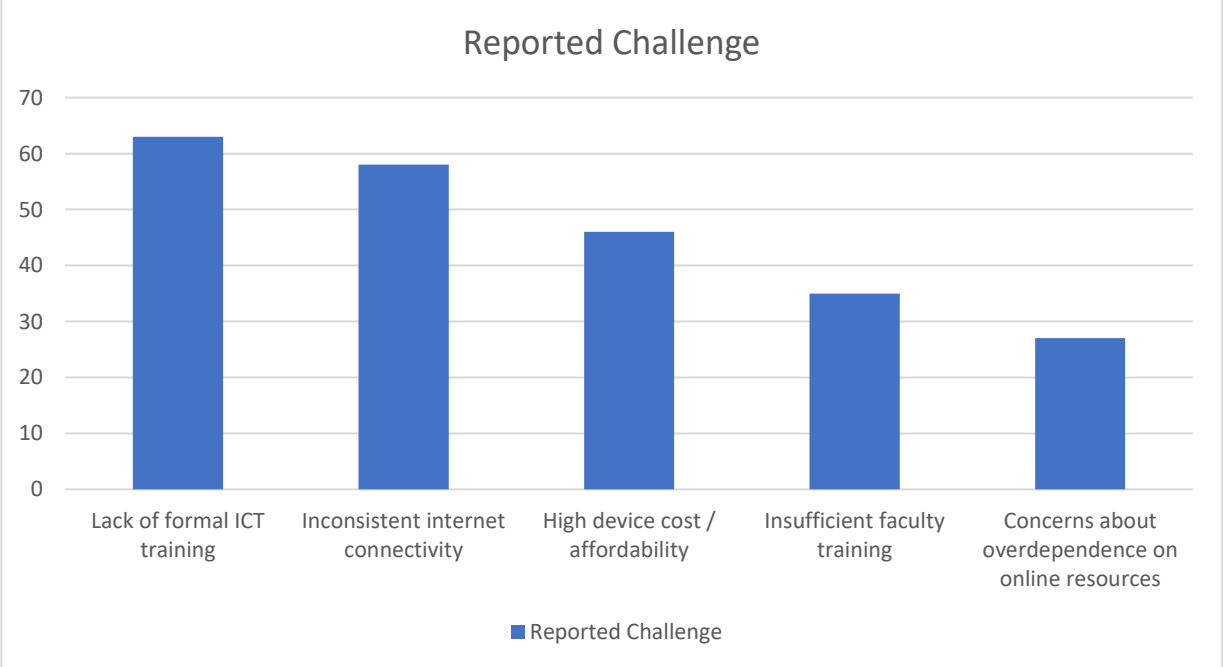
Table 3: Significant Associations Between Student Variables and ICT Perceptions (Chi-Square Test)

Independent Variable	Dependent Variable (ICT Domain)	Chi-Square Value (χ^2)	P-Value
Year of Study	Preference for Digital Simulation	25.84	< 0.01
Year of Study	Usefulness of Digital Radiography Learning	14.21	0.017
Year of Study	Usefulness of Digital Patient Management Modules	12.95	< 0.05
Digital Proficiency*	Preference for ICT-based Assessments	18.45	0.003

Table 4: Challenges to ICT Integration Reported by Students (N=400)*

Reported Challenge	Frequency	Percentage (%)
Lack of formal ICT training	252	63.0
Inconsistent internet connectivity	232	58.0
High device cost / affordability	184	46.0
Insufficient faculty training	140	35.0
Concerns about overdependence on online resources	108	27.0

Figure 3. Challenges to ICT Integration Reported by Students



Analysis of student responses revealed an overwhelmingly positive perception toward the integration of ICT-enabled tools in the dental curriculum. A substantial majority (**92%**) agreed that ICT significantly improves the quality of learning by enhancing access to digital resources, supporting self-directed study, and facilitating better conceptual understanding. Virtual simulation tools were also highly valued, with **85%** of students indicating that simulation-based training strengthened their preclinical confidence and improved their skill readiness before entering clinical settings.Learning management systems (LMS) were well-received, as **78%** of participants preferred LMS-based lecture delivery over traditional didactic methods, citing advantages such as structured course organization, ease of accessing uploaded materials, and flexibility for revision. In addition, **81%** agreed that training in digital patient record systems should be formally incorporated into their education, emphasizing the growing need for digital literacy in modern dental practice.Tele-dentistry emerged as another widely supported domain, with **89%** of students expressing interest in receiving training related to remote consultations, digital patient communication, and online case management. Overall, **91%** of respondents felt that ICT-enabled tools should be systematically and formally integrated into the dental curriculum, reflecting a strong readiness among students to embrace technology-enhanced learning in both preclinical and clinical phases of dental training.

Significant Associations and Reported Challenges

Statistical analysis revealed several significant associations between academic variables and ICT-related perceptions among students. A strong association was identified between the year of study and acceptance of virtual simulation tools (**p = 0.001**), indicating that students in higher years demonstrated greater appreciation for the role of simulation in enhancing preclinical competency. Similarly, a significant association was observed between the year of study and the perceived usefulness of digital radiography learning (**p = 0.017**), suggesting that students with more clinical exposure valued digital diagnostic tools more strongly. Additionally, digital proficiency was significantly associated with preference for ICT-based assessments (**p = 0.003**), highlighting that students with higher digital literacy were more confident and receptive toward technology-driven evaluation methods.Despite the positive perceptions, students also identified several barriers to effective ICT integration. Poor internet access was the most frequently reported challenge (**58%**), reflecting infrastructural limitations that often hinder smooth participation in online classes, simulations, and assessments. High device cost was reported by **46%** of students, indicating financial constraints in acquiring laptops, tablets, or high-performance devices required for digital learning. Insufficient faculty training was highlighted by **35%**, demonstrating the need for structured capacity-building programs to ensure effective teaching through ICT tools. Furthermore, **27%** of students expressed concerns regarding overdependence on online resources, fearing reduced hands-on clinical exposure and potential compromise of practical skills.

These findings collectively underscore the importance of strengthening digital infrastructure, promoting faculty development, and balancing online and offline pedagogical methods to ensure successful incorporation of ICT in dental education.

DISCUSSION

The findings of this study demonstrate a highly positive perception among dental students in Kerala toward the integration of ICT-enabled educational tools into the dental curriculum. Students recognized ICT as an effective means to enhance the quality of learning through improved accessibility, organization, and clarity of academic content. These findings are consistent with global literature, which shows that ICT plays a transformative role in strengthening student engagement, promoting collaborative learning, and enhancing conceptual understanding in healthcare education (Zitzmann et al., 2020).A notable observation from this study is the strong support for digital simulation-based learning. This aligns with previous international research highlighting that simulation tools—such as virtual tooth preparation, 3D modeling, and haptic devices—significantly improve procedural confidence and skill acquisition before clinical exposure. The students' endorsement of simulation technologies underscores an increasing readiness to adopt digital preclinical training methods that reflect modern standards of dental education.The growing relevance of tele-dentistry and artificial intelligence in clinical practice was also reflected in the positive student responses. As tele-dentistry becomes essential for remote consultations, patient triaging, digital communication, and interdisciplinary collaborations, students acknowledge the importance of receiving formal training in these emerging digital competencies. AI-supported learning tools, including diagnostic aids and electronic decision-support systems, further reinforce the need for a digitally empowered curriculum. Despite the overwhelmingly positive perceptions, students identified several essential requirements for the successful implementation of ICT-based learning. These included the need for structured ICT training programs starting from the first year, faculty development workshops to ensure effective ICT-driven teaching, improved digital infrastructure within institutions, and efforts to make digital devices more affordable for students. These concerns echo findings from previous studies emphasizing that both student readiness and faculty preparedness are critical for effective integration of technology in dental education.The incorporation of ICT into dental training aligns closely with competency-based education models, evidence-based practice, and lifelong learning—key pillars of modern healthcare education. ICT enhances students' ability to access up-to-date scientific literature, participate in virtual case-based discussions, engage in online collaborative learning, and develop digital competencies that are increasingly demanded in clinical practice.

Based on the findings, several curriculum recommendations emerge. Introducing an ICT foundational module in the first year can strengthen digital literacy, familiarize students with learning management systems, and build competence in

using e-resources. Virtual simulation modules introduced in the second and third years can improve preclinical skills through digital tooth preparation, haptic feedback, and radiographic interpretation exercises. Digital clinical documentation training during the third and fourth years can equip students to manage electronic health records and standardized patient documentation. During clinical years, tele-dentistry training can prepare students for remote consultation practices, while ICT-based assessments—including OSCE e-stations, digital viva examinations, and secure online testing platforms—can modernize evaluation methods.

Overall, the results affirm that ICT integration is not only welcomed by students but also essential for aligning dental education in Kerala with global standards. Strengthening digital infrastructure, building faculty capability, and developing structured ICT-based curricular components will play a decisive role in preparing future dental professionals for a digitally advanced healthcare environment.

CONCLUSION

This study highlights the strong acceptance of ICT-enabled educational tools among dental students in Kerala, affirming their value in improving learning quality, enhancing preclinical confidence, and preparing students for modern digital practice. Students widely recognized ICT as essential for both academic and clinical training, demonstrating clear readiness for structured integration of digital tools throughout the curriculum. Although challenges such as limited internet access, high device costs, and insufficient faculty training persist, the findings emphasize the need for institutions to strengthen digital infrastructure, provide faculty development, and implement phased ICT modules—including virtual simulation, digital documentation, and tele-dentistry training—to align with contemporary competency-based and technology-driven standards. Overall, systematic ICT integration represents a crucial step toward enhancing student competency, improving patient management skills, and developing digitally proficient, future-ready dental professionals.

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