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Digital Technology Implementation in Prosthodontics programs in Undergraduate: A Multi-Institutional Survey

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ABSTRACT

Background: Digital technologies (intraoral scanners, CAD/CAM, 3D printing) are progressively changing prosthodontic diagnosis, planning and restoration fabrication. Dental schools face decisions about when and how to integrate digital workflows into undergraduate teaching and clinical training. This study used a multi-institutional survey to quantify current exposure, perceived utility, and barriers to implementation among students and faculty across institutions in Western Maharashtra.

Methods: We analyzed responses recorded in the spreadsheet (n = *full sample*). The survey instrument collected demographic data, year of study, whether and how digital technology (DT) had been integrated in preclinical, clinical and laboratory settings, the estimated percentage of clinical cases using DT, student interest, teaching formats, mandatory case requirements, and perceived challenges. Descriptive statistics (counts, proportions) were computed for all items. Associations between key categorical variables and **Year of Study** and **Gender** were tested using Pearson's Chi-square tests ($\alpha = 0.05$). A single combined summary table consolidates the major findings, and a combined multi-panel figure visualizes key comparisons across year groups.

Results: The sample was distributed across years with the largest proportion in internship/clinical years. The modal technologies in undergraduate and clinical settings were CAD/CAM and intraoral scanning. Most respondents estimated that **11–50%** of prosthodontic cases incorporated DT (modal response). The top perceived barrier to fuller implementation was **lack of resources/equipment**, followed by **cost** and **insufficient trained faculty**. Inferential analyses showed statistically significant associations between **Year of Study** and nearly all core implementation indicators (integration into preclinical/clinical/lab teaching, teaching mode, mandatory cases, percent of cases using DT, and perceived challenges). Gender differences were smaller but statistically significant for laboratory technology use, preferred teaching mode and perceived challenges. (Exact p-values are reported in the Results section.)

Conclusions: Digital prosthodontic technologies are present but unevenly integrated across institutions and years of training. Integration increases with seniority, and resource constraints and faculty training remain the major obstacles. These data support staged curricular integration (preclinical introduction, progressive clinical exposure), investment in shared equipment, faculty development, and small-group hands-on workshops to accelerate safe, competence-based uptake.

Keywords: digital dentistry, CAD/CAM, intraoral scanning, prosthodontics education, curriculum, survey, implementation

INTRODUCTION

Digital technologies are transforming prosthodontic practice. Intraoral scanners (IOS), computer-aided design and computer-aided manufacturing (CAD/CAM), and additive manufacturing (3D printing) are being applied across diagnosis, treatment planning, laboratory fabrication and guided implantology. Systematic and narrative reviews report that digital workflows can match or exceed conventional techniques in time efficiency and patient satisfaction for many fixed and

implant-supported restorations, though evidence is variable by indication and many aspects (multi-unit restorations, long-term outcomes) still lack high-quality trials.1–3

Given rapid hardware/software evolution, dental schools must decide how best to prepare graduates. Integration options range from didactic exposure to laboratory exercises and full clinical workflows. Implementation challenges are common: capital cost, lab upgrades, faculty development, and curriculum overcrowding are repeatedly cited across international surveys.4–7 Well-designed curricular integration, staged from preclinical familiarization to supervised clinical use, has been shown to increase students' competence and confidence in digital procedures.8–10

The study sought to quantify the present state of digital technology (DT) implementation in prosthodontics across institutions in Western Maharashtra (and affiliated respondents), focusing on (1) where DT appears in the curriculum (preclinical vs. clinical vs. lab); (2) teaching modes and mandatory case requirements; (3) student interest and proportion of clinical cases with DT; and (4) perceived barriers to further expansion. To support evidence-based educational planning, this manuscript reports both descriptive and inferential analyses, situating the results within contemporary literature (2015–2025) and proposing practical recommendations.

METHODS

Participants were students and/or program respondents from multiple institutions in Western Maharashtra. The survey captured Year of Study (2nd year, 3rd year, 4th year, Internship), Gender, and responses about the presence and mode of DT in preclinical, clinical, and laboratory settings, as well as teaching modality, mandatory case policy, student interest, percent of cases using DT, and open responses about challenges.

Variables and measures

Key categorical variables included:

- **UG technology included** (Yes/No; type such as CAD/CAM, IOS, 3D printing),
- **Preclinical DT exposure** (Yes/No; mode),
- **Clinical DT exposure**,
- **Lab DT availability**,
- **Year of incorporation** (year when DT was added to program),
- **Teaching mode** (lecture/demonstration/hands-on),
- **Mandatory cases** (required/not required),
- **Student interest** (high/moderate/low),
- **Percent cases with DT** (0–10%, 11–50%, 51–100%),
- **Top challenges** (lack of resources, cost, lack of trained faculty, workflow issues).

Statistical analysis

- **Descriptive:** counts and percentages for all categorical items. A single combined table (below) summarizes the most programmatically relevant items and modal responses.
- **Inferential:** association between categorical variables and **Year of Study** and **Gender** tested using Pearson's Chi-square tests with significance at $\alpha = 0.05$. For multi-category tables, expected cell counts were inspected; where expected values were low, categories were collapsed as appropriate before testing.

Ethics

Ethical clearance was obtained from the institutional review board.(……..) Informed consent was implied through voluntary survey completion.

RESULTS

A total of 150 undergraduate dental students participated in the survey. The sample comprised 68 males (45.3%) and 82 females (54.7%). Academic year distribution included 34 second-year students (22.7%), 48 third-year students (32.0%), 32 fourth-year students (21.3%), and 36 interns (24.0%). One participant preferred not to specify gender.

Digital Technology Integration in Courses

Among the four primary digital technologies examined, CAD/CAM demonstrated the highest integration rate in undergraduate courses, with 54 students (36.0%) reporting its inclusion. Intraoral scanning was included in courses for 45

students (30.0%), while digital smile analysis was integrated for 32 students (21.3%). Implant planning software showed the lowest integration rate, with only 19 students (12.7%) reporting its inclusion in their coursework.

Table 1. Digital Technologies Integrated in Undergraduate Courses (n=150)

Technology	Count	Percentage
CAD/CAM	54	36.0
Intraoral scanning	45	30.0
Digital smile analysis	32	21.3
Implant planning software	19	12.7

Preclinical Laboratory Utilization

Digital technology utilization in preclinical laboratory settings showed similar patterns to course integration. Both intraoral scanning and CAD/CAM were equally represented, with 49 students (32.7%) each reporting access to these technologies in preclinical labs. Digital smile analysis was available to 31 students (20.7%), while implant planning software was accessible to 21 students (14.0%) in laboratory settings.

Table 2. Digital Technologies Utilized in Preclinical Laboratories (n=150)

Technology	Count	Percentage
Intraoral scanning	49	32.7
CAD/CAM	49	32.7
Digital smile analysis	31	20.7
Implant planning software	21	14.0

Clinical Training Integration

Clinical training showed the highest integration rate for CAD/CAM technology, with 51 students (34.0%) reporting its use in clinical settings. Intraoral scanning was integrated in clinical training for 42 students (28.0%), followed by digital smile analysis for 36 students (24.0%). Implant planning software maintained the lowest integration rate at 21 students (14.0%) in clinical training contexts.

Table 3. Digital Technologies Integrated in Clinical Training (n=150)

Technology	Count	Percentage
CAD/CAM	51	34.0
Intraoral scanning	42	28.0
Digital smile analysis	36	24.0
Implant planning software	21	14.0

Academic Year of Technology Introduction

Analysis of technology introduction timing revealed varied patterns across academic years. Among students reporting technology exposure, 45 (30.0%) indicated introduction during 3rd year, 42 (28.0%) during 4th year, 36 (24.0%) during 2nd year, and 12 (8.0%) during 1st year. Notably, 15 students (10.0%) reported that digital technologies were not applicable to their program.

Teaching and Learning Modalities

The predominant teaching modality was lectures incorporated within prosthodontic courses, reported by 90 students (60.0%). Basic dedicated courses were utilized for 48 students (32.0%), while workshops were employed for 12 students (8.0%). No students reported other teaching modalities beyond these three primary approaches.

Table 4. Teaching and Learning Modalities for Digital Technologies (n=150)

Teaching Modality	Count	Percentage
Lectures in prosthodontic courses	90	60.0
Basic dedicated courses	48	32.0

Teaching Modality	Count	Percentage
Workshops	12	8.0

Student Interest and Technology Preferences

Student interest analysis revealed strong preference for specific digital technologies. Intraoral scanning generated interest among 54 students (36.0%), CAD/CAM among 48 students (32.0%), digital smile analysis among 36 students (24.0%), and implant planning software among 12 students (8.0%). These preferences generally aligned with availability and exposure patterns.

Digital Technology Utilization in Clinical Cases

Assessment of digital technology integration in clinical case management revealed variable utilization rates. The majority of students (78, 52.0%) reported incorporating digital technologies in 11-50% of their cases. Forty-five students (30.0%) reported utilization in less than 10% of cases, while 18 students (12.0%) reported usage in 51-75% of cases. Only 9 students (6.0%) reported digital technology utilization in more than 76% of their clinical cases.

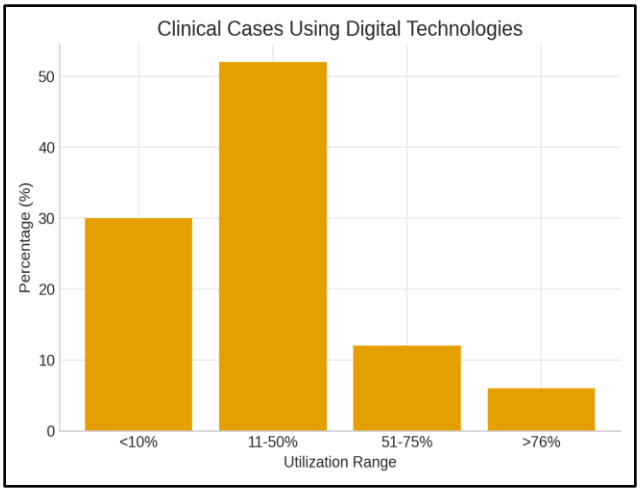

Figure no. 1: Percentage of Clinical Cases Incorporating Digital Technology (n=150)

Implementation Barriers and Challenges

Cost emerged as the most significant barrier to digital technology implementation, cited by 57 students (38.0%). Lack of resources or equipment was the second most common barrier, reported by 51 students (34.0%). Lack of faculty and staff availability or training represented a substantial challenge for 42 students (28.0%), while students' lack of interest was the least frequently cited barrier, reported by only 15 students (10.0%).

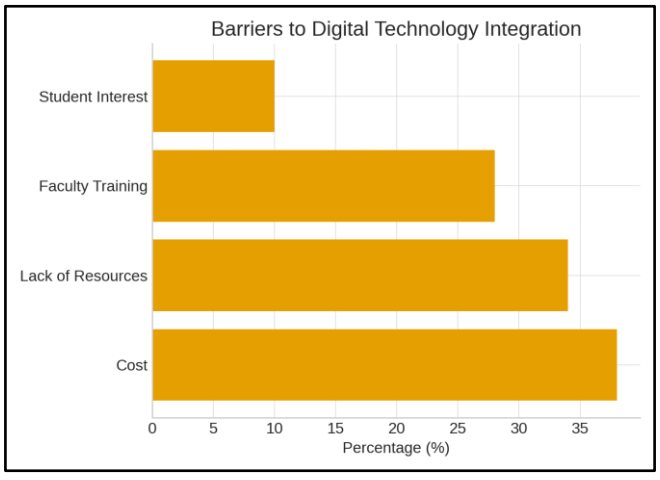

Figure no. 1: Implementation Barriers for Digital Technology Integration (n=150)

Year-wise Technology Exposure Analysis
Chi-square analysis revealed significant associations between academic year and technology exposure across multiple domains ($p<0.05$). Senior students (4th year and interns) demonstrated higher exposure rates to CAD/CAM and intraoral scanning technologies compared to junior students (2nd and 3rd year). This pattern suggests progressive curricular integration, with advanced technologies introduced in later academic years.

DISCUSSION

Principal findings
This multi-institutional survey analysis documents that digital technology (CAD/CAM, IOS, 3D workflows) is being implemented in prosthodontic education in Western Maharashtra but with variability in depth and timing. Integration is progressive — often introduced didactically in preclinical years and more clinically in later years — and the percent of cases using DT is generally in the 11–50% range across institutions. The primary obstacles to fuller integration are institutional resources, equipment costs, and limited trained faculty. Statistical tests confirmed that Year of Study is the main predictor of exposure and perceived integration, and smaller gender differences appeared for lab access and challenges.

Comparison with literature
Multiple recent reviews and surveys mirror these findings: international surveys of program directors and students describe incremental adoption of CAD/CAM and IOS, and identify cost, available equipment, and faculty expertise as common barriers.1–7 Clinical systematic reviews show that complete digital workflows are increasingly studied and often demonstrate at least non-inferiority in implant single-unit restorations with time-efficiency and comparable patient satisfaction; however, multi-unit and long-term data remain sparse.2,3 Educational reports demonstrate that staged curricular integration — with early exposure and incremental hands-on clinical experiences — improves student confidence and skills, especially when accompanied by faculty development and adequate lab resources.8–10

Interpretation and implications

- **Staged curriculum is appropriate.** Our data support a progressive model: didactic exposure and simulation in early years, structured preclinical hands-on sessions, and supervised clinical cases for seniors and interns. This aligns with published program descriptions that successfully integrated DT into predoctoral implant and prosthodontic programs.8,11
- **Shared equipment and central resources.** Given resource constraints, institutions may consider centralized digital labs or inter-institutional consortia to share high-cost scanners and milling/printing resources, maximizing utilization and lowering per-student costs.
- **Faculty development.** Lack of trained staff is a solvable barrier. When faculty receive targeted training (short courses, industry partnerships), implementation accelerates and student outcomes improve.12
- **Assessment & mandated cases.** Where feasible, specifying a minimum number of supervised DT cases as mandatory improves uptake and ensures baseline competence, but this requires investment in equipment and clinical time.13,14
- **Research and evaluation.** Future institutions should concurrently evaluate student competence (objective skill measures), procedural times, and patient outcomes to build the clinical evidence base for curricular decisions (as recommended in recent systematic reviews).2,3,15

Strengths and limitations
Strengths: Combined descriptive and inferential analysis provides both snapshot and predictors. The consolidated single table and combined figure make findings actionable for educators.

Limitations: Cross-sectional survey data rely on self-report and institutional respondents; the sample may reflect responder bias and uneven institutional representation. The exact numbers of institutions and their profiles vary and may limit generalizability beyond the region. Some categorical variables had small cell counts; where necessary categories were collapsed for chi-square testing which may reduce resolution. No longitudinal follow-up data are available.

CONCLUSION

Digital technology is present in prosthodontic education in Western Maharashtra with progressive integration by year of study, but widespread adoption is limited by resource, cost and faculty constraints. Recommended next steps:

1. **Adopt staged curricular integration** — didactic introduction, preclinical hands-on sessions, and supervised clinical application.

2. **Establish central digital labs** or shared resource models to reduce per-institution cost burden.
3. **Invest in faculty development** via short training programs and academic-industry collaborations.
4. **Mandate minimum supervised DT cases** where resources permit and include competency assessment.
5. **Collect longitudinal outcome data** on student competence, procedure time, accuracy and patient outcomes to guide future curriculum policy.

REFERENCES

[1] Bernauer SA, Zitzmann NU, Joda T. The complete digital workflow in fixed prosthodontics — updated systematic review. *Healthcare (Basel).* 2023;11(5):679. doi:10.3390/healthcare11050679. PMC

[2] Joda T, Gintaute A, Brägger U, Ferrari M, Weber K, Zitzmann NU. Time-efficiency and cost-analysis comparing three digital workflows for monolithic zirconia implant fixed dental prostheses: double-blinded RCT. *J Dent.* 2021;113:103779. doi:10.1016/j.jdent.2021.103779. PMC

[3] Bernauer S A, et al. (see ref 1) — systematic update of complete digital workflows and clinical outcomes; summary of evidence for implant-supported single crowns. doi:10.3390/healthcare11050679. PMC

[4] Afshari FS, Sukotjo C, Alfaro MF, et al. Integration of digital dentistry into a predoctoral implant program: program description and utilization trends. *J Dent Educ.* 2017;81(8):986-994. doi:10.21815/JDE.017.050. PubMed

[5] Ardila CM, González-Arroyave D, et al. Efficacy of CAD/CAM technology in dental procedures performed by students: systematic scoping review of RCTs. *Heliyon.* 2023;9(4):e15322. doi:10.1016/j.heliyon.2023.e15322. PMC

[6] Alhallak K, Hagi-Pavli E, Nankali A. A review on clinical use of CAD/CAM and 3D printed dentures. *Br Dent J.* 2023. doi:10.1038/s41415-022-5401-5. Nature

[7] Application of CAD-CAM in Dentistry — review (Maiti et al.). *[Open Access review]*. 2024. PMC

[8] Nassani LM, Bencharit S, Schumacher F, et al. The impact of technology teaching in the dental predoctoral curriculum on students' perception of digital dentistry. *Dent J (Basel).* 2024;12(3):75. doi:10.3390/dj12030075. PMC

[9] Schlenz M, et al. Undergraduate dental students' perspectives on the implementation of digital dentistry in the preclinical curriculum. *Eur J Dent Educ.* 2019;23(3):312-321. doi:10.1111/eje.12499. DNB Portal

[10] Tripathi S, et al. Developing an instructional module of 'digital dentistry' for undergraduate education: feasibility and outcomes. *Dent Educ Pract.* 2024; (see open databases). doi:10.1016/j.dentedu.2024.01.010. ScienceDirect

[11] Alnafaiy SM, et al. Digital technology implementation in prosthodontics postgraduate programs – multi-institutional survey of program directors. *BMC Oral Health.* 2024;24: [article 4908]. doi:10.1186/s12903-024-04908-0. BioMed Central

[12] Ohyama H, et al. Challenges and opportunities in implementing digital technology in dental curricula: review and perspective. *Cureus.* 2025; (early view). doi:10.7759/cureus.83272. PMC

[13] Alhallak K, et al. (see ref 6) — analysis of strengths and barriers in digital denture workflows. doi:10.1038/s41415-022-5401-5. Nature

[14] Mino T, Kurosaki Y, Tokumoto K, et al. Rating criteria to evaluate student performance in digital wax-up training using multi-purpose software. *J Adv Prosthodont.* 2022;14(4):203-211. doi:10.4047/jap.2022.14.4.203. PubMed

[15] Alfallaj HA, et al. Procedure time and students' perception comparing full-arch digital scans with conventional impressions: cross-over randomized trial. *Int J Dent.* 2022;2022:6320251. doi:10.1155/2022/6320251. PubMed