

CHAPTER I

INTRODUCTION

1.1 Background

The field of prosthodontics is undergoing a significant transformation through the integration of digital technologies, such as intraoral scanners, and computer-aided design/computer-aided manufacturing (CAD/CAM). These tools have been demonstrated to improve accuracy, workflow efficiency, patient comfort, and interdisciplinary communication while reducing clinical time and minimizing errors associated with traditional methods (Logozzo et al., 2014; Mangano et al., 2017).

In prosthodontics, digital workflows facilitate the fabrication of various restorations, including zirconia crowns, fixed bridges, complete and partial dentures, and implant-based structures often with greater precision than conventional techniques (Joda, Zarone, & Ferrari, 2017; Ahmed, 2018).

With increasing demands for digitally driven dental care, dental schools globally have begun integrating these technologies into their curricula. In the United States, simulation labs and virtual workflows now commonly form part of undergraduate training (Joda et al., 2022). Despite this trend, recent studies

conducted across different regions, including Saudi Arabia, China, and Romania continue to highlight gaps in students' familiarity with digital prosthodontic tools. For instance, a survey among senior dental students in Riyadh found that although most held a moderately positive attitude, only around two-thirds were aware of systems like Chairside Economical Restoration of Esthetic Ceramics (CEREC), and few recognized applications such as digital smile design or facial scanning (Kakti et al., 2022). Similarly, dental students in Tamil Nadu largely perceived intraoral scanning (IOS) as beneficial but reported limited knowledge and practice with the devices (Manoharan et al., 2024). Comparable results from dental professionals in China revealed solid knowledge and positive attitudes, yet substantial variation remained in practice and depth of understanding across technologies (Chen et al., 2024). These findings underscore the need to evaluate students' readiness and perceptions toward adopting digital workflows in prosthodontics.

Furthermore, empirical research has linked higher levels of knowledge and favourable attitudes with greater intention to use digital dentistry tools in future practice. In a U.S. study, preclinical students who completed digital dentistry didactic courses showed

significantly stronger intentions to implement digital tools, influenced by social norms and perceived self-efficacy (Jones et al., 2021).

In the context of Hasanuddin University in Indonesia, the extent to which undergraduate students are prepared for digital prosthodontics remains undocumented. There is currently limited evidence on students' awareness, perception, and confidence regarding these emerging technologies. As dental education continues to evolve, assessing the knowledge and attitudes of Hasanuddin University dental students will help identify educational gaps, enhance curriculum content, and align training with global standards in digital prosthodontics.

1.2 Problem Formulation

Despite the rapid growth and integration of digital technologies in modern prosthodontics practice, such as CAD/CAM systems, intraoral scanners, and 3D printing there remains uncertainty about whether undergraduate dental students are adequately prepared to adopt and apply these innovations. While global trends show a shift toward digital workflows, the extent of knowledge and the readiness of students at local institutions, such as Hasanuddin University, has not been thoroughly evaluated.

As future dental professionals, students' understanding and attitudes toward digital prosthodontics are essential for ensuring that they can adapt to evolving clinical standards and technological advancements. However, the lack of data on their awareness, perceptions, and curriculum exposure poses a challenge for curriculum developers, educators, and policymakers.

Therefore, this study aims to address the following key questions:

- 1.2.1 What is the current level of knowledge of dental students at Hasanuddin University regarding digital prosthodontics?
- 1.2.2 What are the attitudes and perceptions of these students toward the use of digital technologies in prosthodontic practice?
- 1.2.3 Is there a difference in knowledge and attitudes between preclinical and clinical students?
- 1.2.4 How do students perceive the adequacy of their dental education in preparing them to use digital prosthodontic technologies?

1.3 Research Objectives

- 1.3.1 To assess the level of knowledge of dental students at Hasanuddin University regarding digital prosthodontic technologies (e.g., CAD/CAM, digital impressions).

- 1.3.2 To evaluate the attitudes and perceptions of dental students toward the integration of digital technologies in prosthodontic practice.
- 1.3.3 To identify differences in knowledge and attitudes based on year of study (preclinical vs. clinical students).
- 1.3.4 To determine whether current dental education adequately prepares students for digital prosthodontic procedures.

1.4 Benefits of Research

- 1.4.1 This study will help identify gaps in dental students' knowledge and attitudes toward digital prosthodontics at Hasanuddin University. The results can support curriculum improvement, better prepared students for digital clinical practice, and guide faculty in planning educational upgrades. It may also encourage the use of digital tools in prosthodontics and serve as a reference for future research in digital dentistry education.

CHAPTER II

LITERATURE REVIEW

2.1 Definitions of Key Digital Dentistry Concepts

2.1.1 Digital Dentistry

Digital dentistry encompasses all dental technologies and devices that incorporate digital or computer-controlled components, including CAD/CAM, intraoral scanners, 3D printing, and chairside systems. These innovations enhance efficiency, accuracy, and patient comfort in diagnosis, treatment planning, and prosthesis fabrication (Schlenz et al., 2020; Costa et al., 2020).

2.1.2 CAD/CAM (Computer-Aided Design/Manufacturing)

CAD/CAM in dentistry is the use of computer technology to design and fabricate dental restorations. Computer-Aided Design (CAD) refers to the digital design of restorations based on intraoral scans or other imaging data. Computer-Aided Manufacturing (CAM) is the subsequent fabrication of the designed restorations through milling or 3D printing (Beuer et al., 2008; Dawood et al., 2015).

2.1.3 Intraoral Scanners (IOS)

IOS are handheld devices that capture high-resolution, three-dimensional optical impressions of dental arches using structured light or laser technology. IOS improves patient comfort, eliminates conventional impression materials, and supports faster, more accurate prosthetic workflows (Mangano et al., 2017; Logozzo et al., 2014).

2.1.4 3D Printing in Dentistry

3D printing, or additive manufacturing, builds dental objects layer by layer using biocompatible materials. It is widely used for diagnostic models, surgical guides, implant templates, complete dentures, and even permanent restorations. The method offers high customization, minimal material waste, and rapid turnaround time (Dawood et al., 2015; Fathima et al., 2024).

2.1.5 CEREC (Chairside Economical Restoration of Esthetic Ceramics)

CEREC is a pioneering chairside CAD/CAM system introduced in the 1980s. It allows for same-day ceramic restoration fabrication by integrating digital scanning, on-screen design, and in-office milling. CEREC reduces laboratory dependence, minimizes patient visits, and maintains high clinical accuracy

(Mörmann & Brandestini, 1986; Schlenz et al., 2020).

2.2 Clinical Uses and Success of Digital Methods in Prosthodontics

2.2.1 CAD/CAM Restorations

Karies CAD/CAM-generated fixed restorations, such as crowns and bridges, exhibit strong long-term outcomes. A meta-analysis of tooth-supported all-ceramic prostheses (zirconia and lithium disilicate) revealed pooled 5-year survival rates of 89.7–91.1% and success rates over 90%, with minor technical or esthetic compromises versus conventional methods (Aswal et al., 2023). Another systematic review estimated 5-year survival at 85–100%, and 10-year survival at 71–100%, confirming the clinical reliability of CAD/CAM restorations (Lampl et al., 2023).

2.2.2 Implant-Supported CAD/CAM Prostheses

In full-arch implant-supported frameworks fabricated using digital workflows, a retrospective study revealed remarkable outcomes: 99.1% implant survival and 100% prosthesis success over four years, demonstrating high precision and durability (Turkyilmaz & Hariri, 2018).

2.2.3 Student-Fabricated CAD/CAM Endocrowns

A clinical evaluation of endocrowns placed by supervised undergraduate students reported a 9-year survival rate around 71.8% (Kaplan–Meier estimate), with failures mainly due to ceramic fracture or debonding—reflecting acceptable outcomes under guided training (Operative Dentistry, 2021).

2.2.4 3D-Printed and Digital Dentures

Recent trials comparing 3D-printed dentures versus conventional types found equal or improved retention, comfort, and patient satisfaction. One randomized trial reported significantly better retention and higher oral health–related quality-of-life scores at 3, 6, and 12 months for 3D-printed implant overdentures (Ibrahim et al., 2025). Another crossover study noted 20% of participants preferred digital dentures for requiring fewer visits and quicker fabrication (Kang et al., 2022).

2.2.5 Intraoral Scanners (IOS)

Intraoral scanners replace conventional impressions by capturing precise digital models for crowns, bridges, implant prostheses, and complete arches (Shubham Kumar et al., 2024; Ma et al., 2023). IOS use in implant-supported restorations

shows near 100% prosthetic survival, minimal bone loss (~0.03 mm), and shorter procedure times. Accuracy is excellent for single and short-span restorations, with implant-specific scanners achieving ~99% success. Full-arch scans remain technique-sensitive, as deep cavities and scanning strategies affect precision (Mangano et al., 2024; Özden et al., 2025).

2.3. Integration of Digital Methods into Dental Education

The incorporation of digital dentistry into undergraduate curricula is increasingly recognized as essential. A systematic review of 82 studies showed that digital tools like intraoral scanning and virtual learning platforms can greatly enhance teaching quality and student readiness (Costa et al., 2020). At Justus Liebig University Giessen, two training modules were successfully implemented in preclinical prosthodontics: module I focused on digital analysis of tooth preparations via computer-aided learning (CAL), and module II introduced a full CAD/CAM workflow (Schlenz et al., 2020). Over 90% of participants reported increased confidence and willingness to use intraoral scanners in future clinical practice, although most still preferred human

feedback over automated digital assessments (Schlenz et al., 2020).

2.4. Student Knowledge and Attitudes Toward Digital Dentistry

Several rigorous studies have explored dental students' familiarity with digital prosthodontic technologies (CAD/CAM, intraoral scanners), highlighting a positive perception but limited practical exposure. In a U.S. national survey of pre-doctoral dental students across 17 schools, 87.2% reported receiving CAD/CAM education through lectures and simulations, and 45.2% had experience with intraoral scanning. Attitudes were highly favourable: most students believed CAD/CAM represented the future of dentistry and improved their competence as future clinicians (Alhamed et al., 2022).

At the University of Zagreb, all respondents were aware of CAD/CAM technology, though most had not seen a restoration produced using it. Despite this, the majority expressed strong support for integrating CAD/CAM into their training, citing reduced fabrication time and modern relevance as primary benefits (Šlaj et al., 2019).

A BMC study focusing on IOS perception found that students appreciate digital impressions for their comfort and workflow efficiency but reported consistent barriers: only about half had witnessed the devices in person, and access to clinical use was limited (Ahmed et al., 2021). Students still viewed digital workflows positively, but lack of institutional infrastructure and cost concerns tempered broader adoption.

Finally, a study in Egypt revealed that while students generally possessed moderate to high knowledge and perceptions of digital dentistry, most of their learning occurred outside formal education—via workshops, webinars, or peer discussion. The study recommended integration of hands-on CAD/CAM modules within government dental schools to better align curricula with evolving clinical standards (Hall et al., 2024).

2.5. Gap in Indonesian Context

Although many global studies have assessed dental student preparedness in digital prosthodontics, little to no research addresses Indonesian students specifically at Hasanuddin University. Without baseline data on students' knowledge, perceptions, and curriculum exposure, educators and

administrators lack guidance for aligning training with global standards. This study fills that gap by evaluating dental students in Indonesia, providing critical insights to inform curricular reform, resource planning, and the future of prosthodontic training in a digitally evolving landscape.