

Teaching of Digital Workflow in the Removable Partial Denture Undergraduate Curriculum: A Scoping Review

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ABSTRACT

Context

Digital technology is a rapidly advancing field in dentistry and the implementation of digital workflow in the dental curriculum is a vital part of modern education. To ensure that dental graduates are equipped for independent practice in the digital era, dental curricula must adapt to incorporate these technologies.

Aim

This scoping review explored the extent to which digital workflow is being implemented in the undergraduate removable partial denture (RPD) curriculum.

Methods and materials

A study-specific protocol was developed in accordance with the criteria for conducting a scoping review. Ten electronic databases (Web of Science, ScienceDirect, Scopus, EBSCOhost, Wiley Online Library, PubMed, the Cochrane Library, Medline, Embase, and OpenGrey) were systematically searched for English-language, full-text articles published between 2020 and 2025 to include recent and relevant literature specifically addressing RPD education. Studies were screened based on specific inclusion and exclusion criteria, and relevant data were extracted for analysis.

Results

A database search yielded 89 articles. After removal of 6 duplicates, 83 articles remained and were screened by title and abstract, resulting in the exclusion of 72 articles. Eleven full-text articles were assessed for eligibility, of which 6 were excluded. Ultimately, five articles met the inclusion criteria and were included in the final review. Implementation occurred in preclinical and clinical training, with variations in depth and year-level exposure. Response rates varied from 25% to 85%, affecting generalisability.

Conclusions

This scoping review identified limited evidence of the implementation of digital workflow within undergraduate RPD curricula. Given the small number of studies included, the findings reflect trends in the USA and MENA region and may not be generalisable to other contexts. A common theme across the studies was the identification of barriers to implementation, which included financial constraints, limited faculty training, and infrastructure limitations. Further research is required to determine current educational practices and support broader curriculum development.

Keywords

undergraduate curriculum, digital workflow, dental education, removable partial dentures, CAD/CAM dentistry.

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The authors have no conflict of interest to declare.

INTRODUCTION

Removable partial dentures (RPDs) remain an important treatment modality in the management of partial edentulism, a condition characterised by the absence of one or more natural teeth.¹ The prevalence of partial edentulism remains high and is influenced by increased life expectancy, an ageing population, and improved retention of natural dentition into older age.² A national survey conducted in the UK in 2023 demonstrated a trend toward greater tooth retention among older adults, with only a small percentage being completely edentulous.³

Despite significant advancements in digital dentistry, RPD teaching practices at many universities continue to rely predominantly on conventional workflows, with limited formal integration of digital technologies.⁴ While foundational prosthodontic principles remain constant, digital design, materials, and fabrication methods have significantly altered clinical practice.⁵ Digital workflow in dentistry refers to the integration of digital technologies in the fabrication of a dental prosthesis. In the context of removable partial dentures (RPDs), digital workflow may involve intraoral or laboratory scanning, virtual design of RPD frameworks and components using CAD software and digital fabrication of the final prosthesis via milling or three-dimensional (3D) printing. Digital workflow is increasingly influencing

clinical practice and dental education. Digital tools such as intraoral scanning, CAD, and 3D manufacturing are being incorporated into prosthodontic workflows, with the potential to improve efficiency, precision, and patient-centred care.^{6,7,8} Adoption of digital workflow and 3D printing technologies has increased considerably over the past decade.⁹ Consequently, dental curricula must evolve to reflect technological advancements and ensure graduates are adequately prepared to deliver modern oral healthcare.^{10,11,12}

Digital workflow technologies may offer potential advantages in both clinical and educational contexts, including reduced laboratory procedures, decreased production time, and enhanced learning through interactive and visual teaching approaches.^{4,7,13} However, implementation challenges remain, including financial costs, infrastructure requirements, faculty training, and the rapid pace of technological development.^{5,14} These barriers contribute to variability in how digital workflow is incorporated into undergraduate dental curricula, particularly in the teaching of RPDs.

Although digital dentistry continues to expand rapidly, there is limited consolidated evidence describing the extent to which digital workflows are incorporated into undergraduate RPD education and how institutions are adapting to evolving clinical demands. This gap is particularly relevant within the South African context, where curriculum development must balance technological advancement with local resource considerations and public health priorities.

Therefore, this scoping review aimed to map the existing literature on the incorporation of digital workflow technologies within undergraduate RPD curricula, to describe how digital workflow is being taught, and to identify factors influencing its implementation. The findings are intended to provide evidence that may inform curriculum development in South African dental institutions, while acknowledging that direct application may not be possible due to difference in resources.

The review was guided by the question: *Is digital workflow included in the undergraduate RPD curriculum?*

METHODOLOGY

Study design and methodological framework

This study was conducted as a scoping review to explore the extent to which digital workflow technologies are integrated into undergraduate RPD curricula in dental education. The review was guided by the Joanna Briggs Institute (JBI) framework for evidence synthesis, which outlines a structured five-stage approach to scoping reviews. The JBI methodology was selected because it provides a rigorous framework for mapping emerging and heterogeneous literature and is particularly suited to reviews aiming to explore the breadth, nature, and characteristics of evidence rather than assess intervention effectiveness.^{6,7}

The five stages of the JBI framework included: (1) identifying the research question; (2) identifying relevant studies; (3) study selection; (4) data charting and presentation; and (5) collating, summarising, and reporting the results (Table I).^{6,7} The review was reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines.⁷ In accordance with JBI guidance for scoping reviews, no formal methodological quality appraisal of the included studies was

conducted, as the main aim was to map and synthesise the available evidence rather than evaluate the methodological rigour of the studies.^{6,7}

Three investigators (NA, FK, and RA) were involved in the conceptualisation and design of the review.

Table I. Proposed methodology for the scoping review based on the JBI framework for evidence synthesis.^{6,7}

1. Identifying the research question	Clarifying and linking the purpose and research question
2. Identifying relevant studies	Using a three-step literature search to balance feasibility with breadth and comprehensiveness
3. Study selection	Careful selection of the studies using a team approach and including all levels of evidence, as considered by the JBI levels of evidence
4. Presenting the data	Charting the data in a tabular and narrative format where applicable
5. Collating the results	Identifying the implications of the study findings for policy, practice, or research

Research question

Following refinement of the research objectives, the review sought to explore the integration of digital workflow technologies within undergraduate RPD curricula in dental education, including the extent of implementation, teaching approaches, perceived benefits, and challenges associated with digital workflow adoption.

Eligibility criteria

Inclusion: This review focused on studies published in full-text English between 1 January 2020 and 1 January 2025. This period was selected to include recent and relevant literature specifically addressing the integration of digital workflow in undergraduate removable partial denture education, as earlier studies predominantly focused on fixed prosthodontics.

Exclusion: Studies were excluded if they focused on other dental disciplines, exclusively referenced postgraduate education, non-educational clinical applications, publications outside the specified date range, or non-English language articles.

Information sources and search strategy

A comprehensive search was conducted across ten electronic databases: Web of Science, ScienceDirect, Scopus, EBSCOhost, Wiley Online Library, PubMed, the Cochrane Library, Medline, Embase, and OpenGrey.

Key terms were combined using Boolean operators to maximise sensitivity and specificity. An example search strategy included:

(“Removable Partial Dentures” OR “Removable Partial Prosthesis” OR “RPD” OR “Removable Dental Prosthesis” OR “Removable Prosthodontics”) AND (“Dental Curriculum” OR “Prosthodontic Education” OR “Dental Education” OR

“Clinical Dental Training” OR “RPD Education”) AND (“3D Printing” OR “Digital Workflow” OR “CAD/CAM” OR “Digital Prosthodontics” OR “Digital Dental Education” OR “Digital Fabrication” OR “Digital Removable Prosthesis”).

The search was limited to publications between 2020 and 2025 to ensure relevance of RPD-specific education.

Study selection

Two reviewers independently conducted the literature search and screening process according to predefined inclusion and exclusion criteria. Duplicate records were removed manually following database searches, with records reviewed to identify duplicates both within individual databases and across multiple databases prior to screening. Study selection was conducted in three stages: initial title screening, followed by abstract review, and subsequently full-text assessment for eligibility. Discrepancies between reviewers were resolved through discussion and consensus. A third reviewer acted as an adjudicator when agreement could not be reached; however, adjudication was not required.

Data extraction and charting

Data extraction was conducted independently by two reviewers using predefined data extraction criteria aligned with the objectives of the study. Extracted information included study characteristics, digital technologies utilised,

educational approaches, key findings, phase of teaching and challenges/limitations.

Following independent extraction, reviewers met to compare findings and finalise extracted data through consensus. The third reviewer provided oversight where necessary.

Data analysis and presentation

The study selection process was documented using a PRISMA flow diagram (Fig. 1). Characteristics of included studies were analysed descriptively and synthesised narratively according to the objectives of the scoping review. Data was presented in tabular and narrative formats to provide an overview of digital workflow integration within undergraduate RPD education and to identify trends and gaps for dental curricula.

Results

The database search yielded a total of 89 records, of which 5 studies met the inclusion criteria following title, abstract, and full-text screening (Fig. 1). The included studies primarily consisted of survey-based research examining the implementation, teaching practices, and perceptions of digital workflow technologies in undergraduate dental education. Most of the included studies were conducted in the United States, with one study from the MENA region, reflecting a limited view of the growth of digital technologies in prosthodontic education.

Table II.

STUDY DETAILS						
Article title, journal, author & country of origin	Methods and participants	Focus	Key findings	Phase of teaching	Challenges/ limitations	
Current Implementation of Digital Dentistry for Removable Prosthodontics in US Dental Schools International Journal of Dentistry Y. Ishida, Y. Kuwajima, T. Kobayashi, Y. Yonezawa, D. Asack, M. Nagai, H. Kondo, S. Ishikawa-Nagai, J. Da Silva, S.J. Lee USA Japan	Online survey (15 questions) sent to predoctoral schools (56 schools) and advanced graduate prosthodontics (52 schools) directors.	RPD-specific	CAD/CAM RPDs taught in 12.5% of predoctoral programmes; 25% used in clinical practice.	Preclinical: lecture/ demonstration Clinical: limited hands-on practice	Barriers: funding, resources, time, faculty proficiency, limited clinical opportunities.	
Assessment of Digital Workflow in Predoctoral Education and Patient Care in North American Dental Schools Journal of Dental Education MC. Prager, H. Liss USA	35-question survey sent to 76 dental schools.	General CAD/ CAM	Digital technology widely introduced; however, varies across dental schools	Preclinical: lectures/ demos Clinical: exposure via patient care	Limited equipment; lack of faculty training; regional variability	
Computer-aided Design/Computer-aided Manufacturing (CAD/CAM) Technology in the Undergraduate Dental Programmes in the MENA region European Journal of Dental Education Md. Sofiqul Islam, A. Al-Fakhri, MM. Rahman UAE	20-question online survey; 55 participants	General CAD/ CAM	Digital removable prostheses incorporated, but variable implementation	Preclinical: lectures/ demos Clinical: limited exposure.	Lack of faculty encouragement and support	

STUDY DETAILS					
Article title, journal, author & country of origin	Methods and participants	Focus	Key findings	Phase of teaching	Challenges/ limitations
A survey on utilisation and barriers of digital removable prostheses in US dental education <i>Journal of Dental Education</i> H. Elkassaby, F. Touloumi, W. Auclair Clark, S. Jiang, A. Mahrous, J. Mainelli, M. Moghadam, C. Zemnick, R. Sadid-Zadeh USA	Survey directed to restorative chairs & prosthodontic programme directors; follow-up emails	Digital removable prostheses	Digital removable prostheses incorporated, but variable implementation	Preclinical: demonstrations Clinical: hands-on when available	Limited IT/ lab support, financial constraints, faculty proficiency
Pre-doctoral dental students' computer-aided design/computer-aided manufacturing-related education, knowledge, attitudes and behaviour: A national survey <i>Journal of Dental Education</i> F.J. Alhamed, GF. Neiva, S. Bak, E. Karl, MR. Ingelhart USA	National student survey; distributed via deans to 68 schools; SPSS analysis	General-CAD/CAM	65.6% received hands-on training; generally positive attitudes; senior students more experienced	Preclinical: lectures, small-groups demos, video demos Clinical: hands-on workshops, individual training across 4 years	Low response rate (25%); possible response bias; COVID-19 impact

RESULTS

Thematic synthesis of included studies

The five included studies were analysed thematically to explore patterns in the implementation and teaching of digital workflows within undergraduate RPD education. Thematic analysis identified five key areas: implementation of digital workflow for RPDs, extent of digital workflow teaching, response rates, emerging trends, and barriers to implementation.

RPD-specific Digital Workflow Implementation

Across the included studies, the implementation of digital workflow specifically for RPDs within undergraduate dental education was limited and inconsistent across institutions. Ishida et al.¹⁵ assessed RPD-specific digital workflow, reporting that 12.5% of predoctoral programmes taught CAD/CAM RPDs, while 25% incorporated it into clinical practice, suggesting a disconnect between theoretical teaching and practical application.

The remaining studies primarily focused on general CAD/CAM education rather than RPD-specific applications. Elkassaby et al.⁷ found that removable CAD/CAM technologies were introduced in both clinical and preclinical settings, but implementation varied across programmes, with approximately 29% of programmes reporting no use of digital removable prostheses. Prager et al.⁸ reported widespread but variable incorporation of digital technologies across 54 dental schools, while Islam et al.¹³ (MENA region, general CAD/CAM) noted in some cases students sought additional formal training privately due to limited institutional support. Alhamed et al.¹⁴ reported hands-on experience for 65.6% of students, but the focus was on general CAD/CAM rather than RPD-specific applications.

Extent of digital workflow teaching

The included studies reported the incorporation of digital workflow into undergraduate dental education, within both preclinical and clinical training environments. However, the consistency and extent varied widely.

- Preclinical training: lectures, video demonstrations, small-group demonstrations.
- Clinical training: hands-on workshops, patient-based application.

Only Ishida et al.¹⁵ directly assessed RPD-related teaching. For the studies reporting general CAD/CAM training, exposure to digital technologies included digital scanning, CAD, and 3D manufacturing, but it was not clearly linked to RPD fabrication.

Response rates

Where reported, the response rates to the surveys varied considerably. Alhamed et al. reported a response rate of 25% while Elkassaby et al. reported an 85% response rate; this variability may influence the reliability and generalisability of the findings.

Trends in current digital workflow integration

Current trends demonstrate a gradual increase in the inclusion of digital dentistry, particularly CAD/CAM technologies, within undergraduate dental curricula. All studies reported some degree of exposure to digital scanning and manufacturing; however, access, type of training and implementation varied significantly across institutions and geographic regions.

Barriers to digital workflow implementation

Several recurring barriers to the integration of digital workflow technologies were identified across the studies. Financial constraints associated with equipment acquisition and maintenance were among the most frequently reported challenges.^{7,14} Limited faculty proficiency and insufficient training were also commonly cited as barriers to effective curriculum implementation.^{8,13} Additionally, shortages of adequately trained IT and laboratory personnel were reported as operational challenges.⁶ Time limitations within existing curricula further restricted the integration of digital modules, and disruptions related to the COVID-19 pandemic were noted as influencing teaching delivery and consistency.¹³

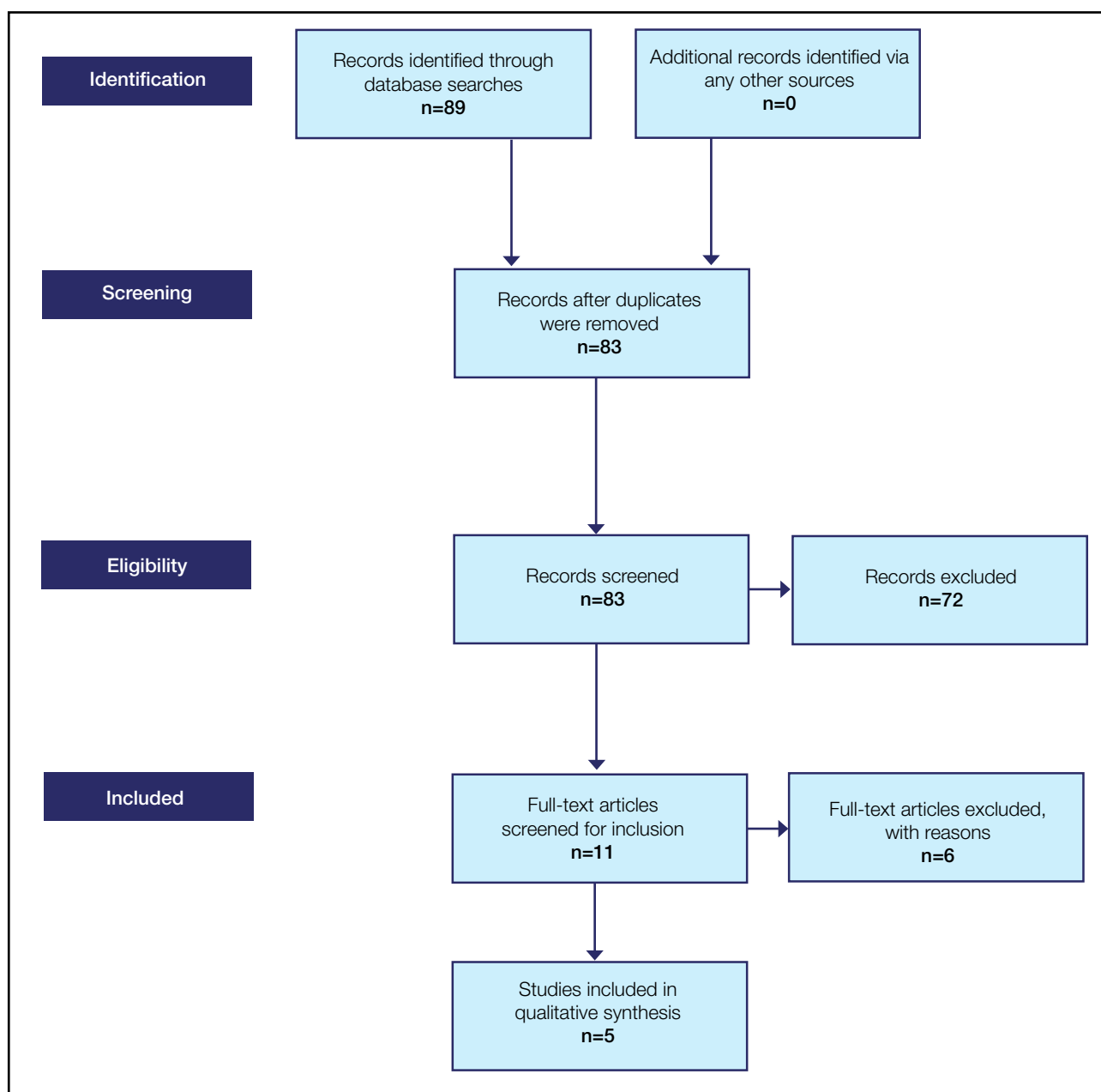


Figure 1: PRISMA Flow Chart for scoping review of undergraduate teaching of digital workflow in the removable partial denture curriculum¹⁰

DISCUSSION

This scoping review explored the extent to which digital workflow technologies are integrated into undergraduate removable partial denture (RPD) education.

The findings indicate that while digital workflow is increasingly recognised as important in dental education, its implementation within RPD education remains limited and inconsistent. For example, Ishida et al. reported that only 12.5% of predoctoral programmes formally taught CAD/CAM fabrication techniques, with digital RPDs used clinically in only 25% of programmes. Similarly, Elkassaby et al. reported that a group of institutions had not implemented any form of digital RPD utilisation, highlighting the uneven adoption of these technologies.

Across the included studies, digital workflow was most introduced through preclinical and clinical training; however,

the extent of integration and opportunities for hands-on learning differed considerably between the institutions. While Alhamed et al. reported that 65.6% of students had received hands-on CAD/CAM exposure and generally demonstrated positive attitudes toward digital technologies, these findings were derived from a single national survey study and were not specific to RPD fabrication. This reinforces the finding that exposure to digital workflow does not necessarily translate into structured RPD-specific training.

A key finding was the disconnect between the identification of digital dentistry as an essential component of modern practice and its practical inclusion within undergraduate RPD education. Although students and faculty members generally reported exposure to CAD/CAM technologies and digital design principles, formal training specific to digital RPD fabrication remained limited. This suggests that while digital dentistry is being introduced broadly within curricula, its application within

removable prosthodontics is still developing. Compared to fixed prosthodontics, where CAD/CAM integration is more widespread, RPD-specific digital training appears to lag, potentially due to differences in resource availability and faculty familiarity. Although direct comparisons were not evaluated within this study, the lower reported rates of RPD-specific integration support this interpretation.

The included studies also highlighted common implementation approaches, including didactic teaching, small group demonstrations, and clinical exposure. However, the variability observed across institutions, including differences in reported equipment availability, faculty proficiency, and laboratory support, suggests that implementation is largely dependent on institutional resources rather than standardised curriculum requirements. For example, Ishida et al. and Prager and Liss identified funding and faculty training limitations as major barriers, while Elkassaby et al. highlighted insufficient IT and laboratory support. The MENA-region study further highlighted limited faculty encouragement as a major barrier.

It is important to note that none of the included studies reported clear accreditation requirements for digital RPD training. The absence of accreditation standards may contribute to differences in curriculum design and student exposure to digital RPD training. Establishing clear guidelines may help institutions implement more consistent digital workflow training, ensuring dental graduates are adequately prepared for private practice.

Several recurring barriers were identified across the studies. Financial constraints associated with equipment acquisition and maintenance were among the most frequently reported challenges. Limited faculty training and confidence in digital technologies were also commonly cited, emphasising the need for professional development initiatives to support curriculum transformation. Operational challenges, including insufficient IT and laboratory support, as well as time limitations within already dense curricula, further restricted integration efforts. Furthermore, the reliance on survey-based evidence indicates that much of the current understanding of digital workflow education is based on institutional self-report rather than objective curriculum evaluation.

Despite these challenges, attitudes towards digital workflow technologies were generally positive among students and faculty, with recognition of their relevance to contemporary dental practice. However, a gap remains between institutional support for digital innovation and its consistent delivery within undergraduate programmes. This highlights the need for structured curriculum planning that balances foundational prosthodontic principles with evolving technological competencies.

LIMITATIONS

The findings of this review should be interpreted considering certain limitations.

First, the small number of included studies, all of which were survey-based, limits the depth and strength of available evidence.

Second, the included studies demonstrated substantial differences in study design, response rates, participant

groups and terminology used to describe digital workflow, making direct comparisons across the studies difficult.

Third, the review was restricted to English-language publications within a defined time frame. This date range was selected to report on current literature specific to digital workflow in removable prosthodontics, as earlier studies predominantly focused on fixed prosthodontics. However, relevant studies published outside of this timeframe or in other languages may have been excluded.

Fourth, no formal quality assessment of the included studies was performed. Due to this study being a scoping review, the focus was on reporting available evidence rather than evaluating study quality.

Finally, most of the studies focused on findings in the USA, with only one study conducted in the MENA region. Therefore, the findings reflect experiences in those regions and may not be generalisable to other countries, including South Africa, where differences in resources may influence the integration of digital workflow technologies.

Finally, several studies reported low response rates, therefore limiting generalisability.

RECOMMENDATIONS

Future research should focus on evaluating educational outcomes associated with digital workflow training in removable prosthodontics and developing standardised frameworks for integrating digital technologies into undergraduate curricula. Longitudinal and mixed-methods studies would provide valuable insight into how digital workflow education influences clinical competence and graduate readiness.

Overall, while digital workflow is increasingly recognised as an essential component of contemporary prosthodontic education, its integration into undergraduate RPD curricula remains uneven. The findings suggest that addressing barriers related to infrastructure, faculty training, and curriculum design may be necessary to ensure that graduates are equipped with the skills required for modern dental practice.

CONCLUSION

This scoping review aimed to explore the extent to which digital workflow is implemented in the undergraduate RPD curriculum.

The findings suggest that while digital workflow is being introduced within undergraduate programmes, structured RPD-specific digital workflow training remains limited and inconsistently implemented. Evidence from the included studies indicates that exposure to CAD/CAM systems does not necessarily indicate that there is formal training in digital RPD fabrication. Implementation is largely dependent on institutional resources, including faculty expertise and infrastructure availability. Overall, the current literature reflects growing recognition of the importance of incorporating digital workflows into prosthodontic education; however, there is uneven integration within the undergraduate RPD curriculum. These findings highlight the need for increased attention to be given to the role of digital technologies in removable prosthodontic education.

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AUTHOR CONTRIBUTIONS

Conceptualisation: RA

Conceived and designed the Protocol: RA

Completed the searches using a well-formulated strategy: NA, FK, RA.

Study Eligibility and Data Extraction Completed: NA, FK, RA.

Manuscript Writing: NA, FK, RM

Edited Drafts: NA, FK, RA, RM. Final Draft Check: NA, FK, RA, RM.

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