

3A Multicentre Evaluation of Web-Based Dental Practicality Index Training for Undergraduate Treatment-Planning Education

Abstract

Aim:

To evaluate whether a web-based Dental Practicality Index (DPI) training improves treatment-planning decision-making skills and confidence among undergraduate dental students.

Methodology:

A multicentre, randomized, prospective interventional study was conducted across 12 dental schools in 10 countries and included 426 final-year undergraduate dental students. Participants were allocated to either a control group (no DPI training) or an experimental group that received DPI training prior to assessment. The intervention consisted of an interactive web-based module introducing the principles and application of the Dental Practicality Index. Following the intervention, both groups completed 15 validated clinical scenarios and a 10-point decision-making confidence questionnaire. Primary outcomes were agreement with expert-referenced scenario decisions and confidence scores. Statistical analysis was performed using non-parametric tests (Wilcoxon; Kruskal–Wallis with DSCF adjustments) and ordinal logistic regression, accounting for the ordinal structure of the confidence measure.

Results:

Students who received DPI training showed significantly higher performance, demonstrated by greater agreement with expert-referenced decisions (median score 7 vs. 6; $p = 0.009$), as well as higher decision-making confidence (median 8 vs. 7; $p = 0.002$). These effects remained significant after adjusting for geographic context, with DPI training independently associated with improved performance (OR = 1.65; 95% CI: 1.10–2.49) and higher confidence (OR = 2.51; 95% CI: 1.46–

4.31). Although regional variations were observed, the benefit of DPI training was consistent across schools. Model calibration and discrimination were acceptable (Hosmer–Lemeshow $p \geq 0.56$; c-statistic ~ 0.64 – 0.73).

Conclusions:

Web-based DPI training improved agreement with expert-referenced treatment-planning decisions and enhanced decision-making confidence among senior undergraduate dental students. Integrating DPI into blended curricula may support standardized decision-making and improved readiness for clinical practice.

Clinical significance:

DPI provides a structured and holistic decision-making framework that can help reduce uncertainty during treatment planning, support more appropriate and timely referral decisions, and ultimately enhance the quality of patient-centered care.

Introduction

Clinical decision-making is a core competency in dentistry, requiring the integration of multiple patient, tooth, and disease-related factors to formulate safe and appropriate management strategies (1). Undergraduate dental students often report limited confidence in synthesising these variables and in determining case complexity or referral needs, indicating the need for structured decision-support tools within training programmes (2,3).

Although several decision-making frameworks exist, their adoption has been limited due to complexity, time requirements, or narrow clinical scope. Many systems address only isolated components of assessment rather than providing a comprehensive evaluative structure (4–6). For example, the Tooth Restorability Index (TRI) quantifies remaining dentine to determine restorability (7), but it excludes broader oral, medical, and contextual considerations essential for real-world planning.

The American Association of Endodontists (AAE) Endodontic Case Difficulty Assessment Form represents a more detailed approach, incorporating patient medical status, anaesthetic considerations, behavioural factors, mouth opening, gag reflex and emergency presentation to classify cases by difficulty and support consistent referral pathways (8). However, its complexity has restricted routine use in general practice, with fewer than 10% of clinicians applying it regularly (9). The Restorability Dentistry Index of Treatment Need (RDITN) offers another structured system, but limited reproducibility of its endodontic component has affected broader uptake (6,10).

The Dental Practicality Index (DPI) was developed to address these limitations by providing a structured and clinically feasible method for evaluating structural integrity, periodontal and endodontic status, and contextual patient factors (11). DPI produces a cumulative score

categorising cases from simple to untreatable, thereby supporting systematic case selection, defining competency boundaries, and informing referral decisions (11). Early clinical studies have reported predictive validity for retreatment outcomes and restoration of root-filled teeth (12–15). Additional research indicates DPI improves consistency of decisions among dental undergraduate and postgraduate learners and enhances alignment with expert consensus (3,16). Its structured design mitigates variability by incorporating restorability, periodontal, endodontic and patient-specific domains.

Recent developments in dental education including global expansion of online instructional platforms have increased the integration of digital tools into curricula. Students report valuing online video-based instruction, tutorials and flexible digital resources as complements to traditional learning environments (17). Consequently, blended learning models have become more prominent, supporting continuity and accessibility of instruction (18).

Given these developments, the present multicentre investigation evaluates whether a web-based DPI training module enhances decision-making performance and self-reported confidence among undergraduate dental students. The present study should be understood within the context of structured decision-making. Specifically, it evaluates students' ability to apply the Dental Practicality Index (DPI) using a guided framework following web-based instruction, rather than assessing independent clinical decision-making competence. Therefore, the focus of this study is on the teachability, usability, and standardised application of DPI in undergraduate dental education across multiple institutions.

Clinical Significance and Anticipated outcome

DPI training has the potential to enhance the consistency and reliability of clinical decision-making among undergraduate dental students by providing a structured and reproducible assessment

framework. Improved confidence and more uniform case-selection decisions may reduce inappropriate or overly complex treatment choices and support safer referral patterns.

Methodology

Ethical approval

This study was approved by the Institutional Review Board (IRB) (protocol number: 202409061) prior to participant enrolment. All participants received a study information sheet and electronic informed consent form outlining the study objectives, procedures, voluntary participation, and data confidentiality. Participants were informed that they could withdraw at any time without penalty.

Study design and Setting

The study was designed to assess students' performance in applying a structured decision-making tool (DPI) within standardised scenarios. It does not aim to evaluate broader clinical reasoning in unstructured clinical environments but rather the effectiveness of an educational intervention in improving DPI-based application.

The web-based DPI training module consisted of a structured, interactive learning sequence designed to guide students through the principles and application of the Dental Practicality Index. The module included step-by-step explanations of DPI criteria, illustrative clinical cases, and decision-making pathways that demonstrated how individual parameters contribute to overall treatment planning. Learners engaged with case-based scenarios requiring selection of DPI scores, followed by immediate feedback and explanation to reinforce correct application. The training was self-paced and standardized across participating institutions to ensure consistency in instructional delivery.

A randomized prospective interventional study was conducted using a secure web-based platform across multiple centers. Dental schools were invited via email through Heads of Institution or Department to facilitate participation and distribute access links to final-year undergraduate dental students. All country-specific facilitators received standardized training on the workflow to ensure consistency and prevent deviations. Final-year undergraduate dental students were chosen because they represent the stage at which learners are expected to transition from supervised training to independent clinical decision-making. At this point in the curriculum, students routinely engage in diagnostic reasoning, case assessment, and treatment planning, making them an appropriate population for evaluating structured decision-support frameworks such as the Dental Practicality Index (DPI).

Sampling and sample size

The study used convenience sampling to ensure practical and consistent recruitment of Final-year undergraduate dental students across multiple international institutions, as a definitive global population frame for this group does not exist. In the absence of an accurate total population estimate, the minimum required sample size was calculated using the CDC's Epi Info™ StatCalc tool, applying standard parameters for survey-based educational research: a 95% confidence level, a 5% margin of error, and a large/unknown population size, as recommended when true denominators cannot be reliably determined. This calculation produced a minimum requirement of $n = 323$ participants. To safeguard against potential non-response and incomplete submissions across centres, a 10% attrition adjustment was applied, resulting in a target sample of approximately 350 students. Ultimately, participation exceeded this threshold, with 426 final-year

undergraduate dental students completing the study, thereby providing adequate statistical precision for all planned analyses.

Inclusion criteria: (i) enrolled as final-year undergraduate dental students, (ii) able to access the web-based application, and (iii) provided electronic informed consent.

Exclusion criteria: (i) prior formal training in DPI, (ii) incomplete baseline data or failure to complete mandatory study components, and (iii) withdrawal at any point.

Randomisation and allocation

To ensure unbiased assignment, participants were allocated to the two study groups using computer-generated 1:1 randomisation embedded within the secure web-based platform. The system automatically randomised each consenting student to either the control group (no DPI training) or the experimental group (DPI training prior to scenario assessment), with allocation concealment maintained throughout. Because randomisation occurred at the individual rather than school level, group sizes within each dental school were not expected to be evenly distributed, and no manual adjustment was made to force equal numbers per site.

The study protocol specified that the total number of students randomised across all participating centres should achieve a minimum of 175 participants per group, ensuring adequate statistical power for the primary analyses. Anticipated variation in school-specific enrolment numbers and participation rates was also accounted for prior to study initiation, as differences in institutional cohort sizes were expected to produce natural variability in per-school group distribution rather than systematic imbalance. Similarly, known curriculum heterogeneity across international dental schools was addressed at the design stage through an analytical rather than stratified allocation

approach; all planned statistical models were cluster-adjusted at the dental-school level to control for institutional differences in teaching exposure and baseline competencies. These methodological considerations were incorporated before data collection began to maintain scientific rigour while preserving feasibility across multiple global centres.

Intervention: DPI training

After registering through the web-based DPI training platform, participants in Group 1 (control) completed a pre-DPI training assessment consisting of 15 clinical case scenarios designed to evaluate baseline decision-making performance. For each scenario, participants selected one of four management options: (i) no treatment needed, (ii) simple treatment indicated, (iii) complex treatment indicated, or (iv) leave/extract the tooth. Each scenario had a single correct response predetermined by an expert consensus panel in accordance with established clinical guidelines, consistent with the methodology described by See *et al.* (16). A cumulative performance score was generated by summing the number of correct responses across all scenarios. Participants were allotted two minutes per case and subsequently completed a 10-point Likert confidence questionnaire based on the Academic Behavioural Confidence (ABC) scale (19).

On the same day, Group 2 (experimental) undertook the web-based DPI training, which included an interactive video, presentation slides, and case-based discussion activities. The training covered DPI principles, indications, and application to structured clinical decision-making. Following completion of the training, Group 2 participants completed the post-DPI training assessment, answering the same 15 clinical scenarios and selecting one of the four management options using DPI-informed reasoning. They also completed the ABC-based confidence questionnaire. All assessments and questionnaires were submitted electronically via the secure web platform.

Conducting both group activities on the same day minimized the risk of cross-group contamination.

Consensus panel

A panel of three experts (each with ≥ 15 years of teaching experience) validated the clinical cases and treatment options. All panel members were trained in DPI assessment. A pilot study with 10 cases was conducted, and Inter-observer agreement among the experts was initially assessed using pairwise Cohen's kappa during the pilot phase to ensure a high level of consistency in scenario interpretation. A threshold of $\kappa > 0.80$ was considered indicative of strong agreement prior to finalising the cases. This reference standard represents a consensus-based guide rather than an absolute clinical truth, acknowledging that alternative treatment decisions may also be clinically valid.

Training module development

The DPI training module was developed using Storyline 360 and PowerPoint slides, incorporating:

- Introduction to DPI and its indications,
- Case-based discussions with four treatment options,
- Interactive elements (click, hover, select),
- Voiceover narration,
- Practice scenarios for self-assessment.

Web-based application features

The application included:

- User account management (registration, login, secure verification),
- Institutional metadata (school and country),
- Assessment workflow (test first or training first),
- Educational content delivery (videos, slides, downloadable materials),
- Communication tools (messaging, notifications, forum),
- Analytics dashboards (progress tracking, reporting).

Outcome measures

- Agreement with expert-referenced scenario decisions (Group comparisons: Control group (no DPI training) or an experimental group that received DPI training prior to assessment).
- Confidence scores (Likert scale).

Data collection and analysis

Given the multicentre nature of the study, participants were nested within institutions. Such clustering can be accounted for using multilevel statistical approaches or by adjusting for intra-group correlation to ensure more robust estimates.

Descriptive statistics was carried out on the data to summarize participant characteristics, test results, and confidence levels. Categorical variables were presented as frequencies and percentages, and continuous variables were summarized using means and standard deviations (SD) as well as medians and interquartile ranges (IQR).

Group differences between participants who completed the DPI training and those who did not were evaluated using the Wilcoxon rank-sum test for continuous variables and the chi-square test or Fisher's exact test, as appropriate, for categorical variables.

The Kruskal-Wallis test was used to compare test Result and Confidence Level, across the ten countries. When the overall test indicated statistically significant differences, post-hoc pairwise comparisons were conducted using the Dwass-Steel-Critchlow-Fligner (DSCF) procedure, a nonparametric multiple-comparison method appropriate for ranked data that controls the familywise error rate.

Normality was assessed using the Shapiro-Wilk test, supported by visual inspection of histograms and Q-Q plots. Both test result and confidence level demonstrated statistically significant departures from normality, confirming the appropriateness of nonparametric procedures for all between-group and cross-country comparisons.

Sensitivity analyses were conducted using ordinal logistic regression (cumulative logit models) to evaluate whether cross-country differences and the effect of DPI training on test result and confidence level persisted after adjustment for DPI training status (no DPI training vs. had DPI training). Proportional odds assumptions were assessed using score tests. Minor deviations were detected in some models; however, the cumulative logit framework remained appropriate for sensitivity analyses aimed at evaluating the robustness of study conclusions.

All statistical tests were two-sided with a significance level of 0.05. Analyses were conducted using SAS® version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

(1) Participant Characteristics (Table 1)

A total of 426 students from 10 countries and 12 dental schools participated. Most were from India (24.7%) and Indonesia (23.9%), followed by the Dominican Republic (12.4%), Brazil (7.8%), Malaysia (7.0%), Greece (6.3%), and others (3.3%–4.9%). Overall, 54.7% completed DPI training before assessment (experimental group). Median test score was 6 (IQR: 5–8; mean 6.5 ± 2.2), with

61.7% scoring 6–10. Confidence was high (median 7; IQR: 6–10; mean 7.4 ± 2.2), and 82.4% rated confidence between 6 and 10.

(2) Comparison by DPI Training Status (Table 2, Figure 1new)

Participants with DPI training (experimental group) scored higher than those without DPI training (control group) (median 7 vs. 6; $p = 0.009$). Test score distribution differed significantly ($p = 0.029$): without DPI training (control group) 37.8% scored 1–5, 59.6 % scored 6–9, and 2.6 % scored 10–15; with DPI training (experimental group) the score distribution was 30.1 %, 63.5 %, and 6.4 % respectively.

Confidence was also greater among DPI trained participants (median 8 vs. 7; $p = 0.002$). They had higher proportions in the 6–8 range (52.8% vs. 50.3%) and 9–10 range (34.8% vs. 25.9%) ($p = 0.002$). Overall, DPI training was associated with improvements in decision-making performance ($d = 0.27$, 95% CI 0.08–0.46) and confidence ($d = 0.33$, 95% CI 0.13–0.52) as seen in Figure 1.

(3) Test Results Across Ten Countries (Table 3A, Figure 2)

Test results differed significantly across countries (Kruskal–Wallis, $p < 0.001$). Post-hoc pairwise comparisons using the Dwass-Steel-Critchlow-Fligner (DSCF) method identified three major performance tiers A, B, and C, with several countries falling into overlapping transitional groups (AB and BC). The highest-performing group (A) included Brazil, Lebanon, and Greece (median 8–9; mean 7.9–8.4). The upper-intermediate group (AB) comprised the United Kingdom, Oman, and Malaysia (median 6–8; mean 6.9–7.6), overlapping with both A and B tiers. The mid-tier group (B) included the Dominican Republic (median 7; mean 6.5). The lower mid-tier (BC) consisted of Bosnia & Herzegovina and India (median 6; mean 5.9–6.0), while Indonesia formed

the lowest-performing group (C) with a median of 5 and mean of 5.6. Overall, results show clear geographic variation, with Brazil, Lebanon, and Greece leading, Indonesia lowest, and other countries occupying transitional positions. These distinctions remained significant after DSCF adjustment.

(4) Confidence Levels Across Ten Countries (Table 3B, Figure 3)

Confidence levels differed significantly across countries (Kruskal–Wallis, $p < 0.001$). DSCF analysis identified two main tiers with a transitional group (A, AB, B). The highest-confidence group (A) included Brazil, Dominican Republic, Bosnia & Herzegovina, United Kingdom, and India, all with median confidence of 8 (IQR 6–10 or 7–10) and mean scores 7.70–7.83. The intermediate group (AB) comprised Oman, Malaysia, and Indonesia, with median 7 (IQR 5–10) and means 6.50–7.20, overlapping with both A and B tiers. The lowest-confidence group (B) included Lebanon and Greece, with medians 6–6.5 (IQR 5–8) and means 6.70–6.79. Overall, confidence showed clear variation: five countries demonstrated consistently high confidence, three occupied a middle ground, and two had the lowest levels. These patterns remained significant after DSCF adjustment.

(5) Sensitivity Analyses Using Logistic or Ordinal Logistic Regression Analysis

Because DPI training is a strong predictor of both test performance and confidence, sensitivity analyses were conducted to determine whether cross-country differences remained significant after adjusting for DPI training status. Before modelling, we confirmed that DPI training participation was distributed similarly across the ten countries ($\chi^2(9)=5.55$, $p=0.784$; Table 2), indicating no evidence of differential access to DPI training that might bias cross-country comparisons. Across countries, the proportion of participants who completed DPI training ranged from 40% to 67%,

demonstrating broadly comparable exposure to the training program across regions. This lack of association between country and DPI training supports the validity of subsequent adjusted analyses.

A. Sensitivity Analysis for Test Results

A cumulative logit model evaluated test performance (1–5, 6–10, 11–13) by DPI training and country, using Indonesia as the reference. The proportional-odds assumption was slightly violated ($\chi^2(10) = 19.24$, $p = 0.037$) but acceptable. DPI training significantly improved performance (OR = 1.65; 95% CI: 1.10–2.49; $p = 0.016$), consistent with the main analysis. Country had a strong effect ($\chi^2(9) = 56.27$; $p < 0.001$). Brazil (OR = 13.64), Lebanon (OR = 14.30), Oman (OR = 13.75), Greece (OR = 7.54), Malaysia (OR = 5.18), UK (OR = 5.45), and Dominican Republic (OR = 2.59) scored higher than Indonesia; Bosnia & Herzegovina and India did not differ. Model fit was good (Hosmer–Lemeshow $p = 0.56$; $c = 0.716$).

B. Sensitivity Analysis for Two-Level Confidence

Binary logistic regression comparing high (6–10) vs. low (1–5) confidence, controlling for DPI training and country (Greece as reference), again showed DPI training as a strong predictor (OR = 2.51; 95% CI: 1.46–4.31; $p = 0.001$). Country differences remained ($\chi^2(9) = 29.55$; $p = 0.0005$). Brazil (OR = 6.19; $p = 0.034$) and India (OR = 4.52; $p = 0.009$) were significantly higher than Greece; others showed nonsignificant increases. Model fit was excellent (Hosmer–Lemeshow $p = 0.999$; $c = 0.733$).

C. Sensitivity Analysis for Three-Level Confidence

Ordinal logistic regression (low 1–5, moderate 6–8, high 9–10) confirmed DPI training as a significant predictor (OR = 1.84; 95% CI: 1.27–2.68; $p = 0.001$). Dominican Republic (OR = 2.75; $p = 0.028$) and India (OR = 2.87; $p = 0.012$) reported higher confidence than Greece; other countries showed nonsignificant increases. Model calibration was good (Hosmer–Lemeshow $p = 0.647$; $c = 0.636$).

Summary: DPI training consistently improved performance and confidence across all models, independent of country. Cross-country differences persisted but were less marked for confidence.

Discussion

This multi-centre, randomized, prospective interventional study evaluated whether web-based Dental Practicality Index (DPI) training enhances final-year undergraduate dental students' agreement with expert reference scores on treatment planning and clinical decision-making, and influences self-reported confidence in those decisions.

The observed improvements in performance should be interpreted as enhanced proficiency in applying the structured rules and framework of the Dental Practicality Index, rather than as evidence of improved independent clinical decision-making ability. While DPI provides a systematic approach to treatment planning, it does not fully capture the complexity and contextual variability of real-world clinical decision-making. The slightly larger effect observed for confidence compared with decision-making performance may indicate that DPI training primarily enhanced learners' perceived preparedness and assurance when approaching diagnostic tasks, with smaller but measurable gains in objective performance. Even modest improvements in decision-making and confidence may be educationally meaningful when interventions are low-cost, easily

disseminated, and capable of reaching large numbers of learners across multiple institutions. The scalability of DPI training may therefore amplify its practical impact despite relatively small individual-level effects.

Across analytic specifications, DPI training was associated with higher agreement with expert benchmarks and increased confidence, indicating that structured decision frameworks can support more consistent judgements among senior dental undergraduates. The DPI differs from indices that address narrower facets of treatment planning. For example, the Tooth Restorability Index (TRI) primarily appraises remaining dentine (7), and the Restorability Dentistry Index of Treatment Need (RDITN) categorises restorative complexity but faces reproducibility challenges in endodontics (6, 10). In contrast, the DPI integrates structural integrity with periodontal and endodontic status and incorporates patient-specific factors such as medical history and treatment needs (11, 20). By providing explicit criteria for classifying complexity and determining treatability, the DPI offers a transparent scaffold that can reduce decisional uncertainty and promote consistent, criterion-based judgements (12–15). Previous studies have shown that DPI training improves agreement between learners and expert panels (3, 16) and helps address uncertainty around referral thresholds encountered by students (1). The current findings extend this literature by demonstrating that a brief, standardised training module can move learners' treatment plans towards expert-established reference scores while also increasing their reported confidence.

Differences between countries could be attributed to variations in curriculum design and clinical exposure. Programs that integrate comprehensive patient care early in training, as recommended by European frameworks, may produce graduates with stronger decision-making skills (21). Such

curricula emphasise case-based learning and interdisciplinary planning, which likely contribute to improved performance. In contrast, programs that rely heavily on preclinical or discipline-specific instruction may delay the development of holistic reasoning, potentially explaining lower performance in some regions. While country-level comparisons should be interpreted cautiously given sample size variability, these findings highlight the broader need for alignment in educational approaches to support consistent development of clinical reasoning skills across settings (22).

Country-level findings should be interpreted as exploratory, given variations in sample sizes across participating institutions, and are intended primarily to reflect the cross-context applicability of the DPI framework rather than definitive comparisons.

The observed improvements in agreement with expert reference scores suggest that DPI training clarifies evaluative criteria and reduces unwarranted variability in student decision-making. For curricula, integrating DPI into blended learning interactive web modules, case-based seminars, and assessed practical offers a scalable mechanism to make expert decision processes more explicit and align undergraduate training with evidence-based protocols (12–15, 21, 22). In clinical contexts, clearer and more reproducible judgements regarding restorability, endodontic prognosis, and periodontal considerations may support more appropriate treatment planning and referral pathways, while also enhancing communication with patients. These directions are consistent with contemporary consensus recommendations emphasising comprehensive, integrated care pathways (23).

The study design incorporated an internal comparator to approximate baseline knowledge. Specifically, students who attempted the case scenarios without exposure to the DPI training

module were considered to represent baseline decision-making performance and confidence levels. These outcomes were then compared with those of students who completed the web-based DPI training module.

To ensure comparability and minimize curricular variations, participants from each participating dental school were divided into two groups (intervention and control) within the same cohort. This approach allowed both groups to originate from the same institutional and educational environment, thereby reducing potential discrepancies in curriculum, teaching methods, and clinical exposure.

Furthermore, only final-year undergraduate dental students were included to ensure that all participants had completed core clinical training and were at a comparable stage of education where treatment planning is routinely expected. As participants were clustered within institutions, shared educational environments may have influenced responses. Future analyses may benefit from multilevel modelling to further account for this structure.

Strengths and Limitations

A key strength of this investigation is its large and internationally diverse cohort, comprising 426 final-year undergraduate dental students across 10 countries and 12 dental schools. This exceeds the sample size requirement and enhances external validity, particularly when compared with single-institution or single-country studies. The multi-centre randomized prospective design, combined with allocation concealment and same-day administration, minimised contamination between groups and strengthened inference. Methodological rigor was further supported by the

use of expert-validated reference scores, with near-perfect interobserver agreement (Cohen's kappa > 0.80), ensuring high-quality criterion standards for assessing agreement.

The web-based platform ensured standardised delivery of training content, uniform timing, and full digital logging for precise data capture, reducing variability in instructional exposure. Analytical robustness was supported by the combination of non-parametric methods (Kruskal–Wallis test with DSCF adjustments) and multivariable modelling (binary and ordinal logistic regression), all of which yielded consistent direction and magnitude of effects. Evaluating both agreement with expert reference scores and self-reported confidence provided complementary insight into the educational impact of the DPI intervention. Collectively, these features contribute to the global relevance and methodological strength of the study.

Despite these strengths, several limitations must be acknowledged. Although the overall sample was large, country-level sample sizes varied substantially, with some sites contributing small cohorts. These numbers are not nationally representative, and participation was voluntary and dependent on local site engagement. Consequently, selection bias, between-site imbalance, and reduced precision in estimates for smaller countries are possible. While regression adjustment accounted for measured confounders, it cannot fully mitigate instability arising from sparse data, nor can it address unmeasured site-level influences such as instructor variability, curricular structure, or local case complexity exposure.

The confidence measure, although widely used, was self-reported and vulnerable to social desirability, cultural response patterns, and differences in scale interpretation. The observed dissociation between high confidence and lower agreement in some settings underscores the need for caution when interpreting confidence as an indicator of competence. Furthermore, the

single-item format limits assessment of confidence calibration and does not permit evaluation of internal consistency.

While a significant increase in self-reported confidence was observed following the intervention, this should not be equated with improved clinical competence or higher-order reasoning ability.

The study's immediate post-training design captures short-term learning gains but does not evaluate retention, transfer to authentic clinical environments, or patient-level outcomes. While the DPI-based test scenarios were validated by experts, vignette-based assessments necessarily simplify clinical complexity. Real-world decision-making is influenced by contextual factors including patient preferences, comorbidities, behavioural considerations, and resource variability that cannot be fully represented in structured scenarios.

Statistically, the proportional odds assumption was marginally violated in the three-level confidence model, indicating that cumulative logit estimates should be interpreted cautiously, even though the direction of effects remained stable across modelling approaches. Additionally, linguistic differences, curricular variations, and disparities in prior exposure to complex cases across participating countries could act as residual confounders despite randomisation.

Another limitation is that the outcome measures are based on structured, DPI-specific scenarios, which may limit generalisability to unstructured clinical environments requiring nuanced judgement beyond algorithm-based decision frameworks.

Future Directions

To strengthen future studies, several methodological improvements can be made. Using stratified or cluster-based sampling with minimum participant numbers at each site would improve representativeness and reduce imbalance between countries. Confidence should be assessed using multi-item scales, calibration measures, and behavioural indicators such as referral patterns or decision-making efficiency. These approaches would provide a more comprehensive understanding of learner self-efficacy.

Long-term follow-up and linkage to real educational or clinical performance outcomes would help determine whether observed improvements are sustained and translate into better patient care. Future research should also evaluate how effectively students retain and apply DPI principles in clinical practice, using outcomes such as treatment completion, retreatment rates, and patient-reported experiences.

Cluster-randomised or stepped-wedge designs across multiple institutions could further clarify how curriculum structure and local context influence training effectiveness. Mixed-methods approaches, including think-aloud protocols and qualitative interviews, may provide deeper insights into how students interpret DPI criteria and navigate complex clinical decisions. Additionally, examining differential item functioning across languages and cultures is important to ensure equitable assessment across diverse educational settings.

Conclusion

Web-based DPI training significantly improved final-year undergraduate dental students' decision-making and their confidence in treatment planning, demonstrating a consistent benefit across countries. These findings support DPI as a scalable tool for strengthening clinical

decision-making at the transition to independent practice. Further research should assess long-term retention and clinical impact.

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