Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Peer Teaching Supports Clinical Reasoning in Pediatric Dentistry Education

Dusan Surdilovic

surdilovic74@gmail.com

RAK College of Dental Sciences, RAK Medical & Health Sciences University

Fadia Awadalkreem

RAK College of Dental Sciences, RAK Medical & Health Sciences University

Research Article

Keywords: Cooperative learning, Jigsaw method, Health professions education, Clinical reasoning, Communication skills, Knowledge retention, Educational assessment, Randomized controlled study

Posted Date: June 28th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9757556/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

Developing clinical reasoning, communication skills, and durable knowledge retention is a persistent challenge in health professions education. Cooperative learning approaches such as the Jigsaw method have been proposed as learner-centered alternatives to traditional lecture-based instruction; however, evidence from randomized studies using objective performance-based assessments remains limited, particularly in disciplines that require integrated cognitive and interpersonal competencies.

Methods

This parallel-group randomized controlled study compared a Jigsaw-based cooperative learning intervention with traditional lecture-based instruction among undergraduate dental students in a pediatric dentistry course. Participants were randomly allocated to the intervention or control group. The primary outcome was OSCE-based clinical reasoning, assessed with a standardized analytic rubric. Secondary outcomes were diagnostic accuracy, communication performance in a standardized parent-actor simulation, and knowledge retention assessed four weeks after the intervention. Outcome assessors were blinded to group allocation to reduce detection bias.

Results

Ninety-eight students completed the study. Compared with the control group, the Jigsaw group demonstrated significantly higher clinical reasoning, diagnostic accuracy, communication performance, and four-week knowledge retention ($p < 0.01$). The intervention group also reported higher learner engagement.

Conclusions

Within this educational context, a structured Jigsaw-based cooperative learning intervention was associated with improved clinical reasoning, diagnostic accuracy, communication performance, and knowledge retention compared with traditional lecture-based instruction. Consistent with contemporary competency-based education frameworks, these findings suggest that combining peer teaching with objective performance-based assessment may support stronger learning outcomes. The results also highlight the value of OSCEs and standardized communication tasks for evaluating learner-centered instructional designs, although they should be interpreted cautiously and not as evidence of broad curriculum superiority or of direct transfer to clinical practice.

1. Introduction

High-quality pediatric dentistry education requires teaching methods that integrate cognitive knowledge with clinical reasoning, diagnostic accuracy, communication skills, and behavior management. Traditional lecture-based instruction often promotes passive learning, which may be insufficient to equip students with the competencies needed to manage complex pediatric clinical scenarios (1). This limitation underscores the need for instructional strategies that foster clinical reasoning, collaborative learning, and performance-based assessment. Contemporary educational theory emphasizes learner-centered approaches that promote students' active engagement, deeper understanding, and long-term knowledge retention. Within medical and dental education, active and cooperative learning models have gained prominence owing to their positive effects on student engagement, collaboration, and problem-solving across a range of applications (2). Among these models, team-based learning has been associated with improved knowledge retention and stronger academic outcomes across healthcare disciplines (3).

The Jigsaw model, introduced by Aronson in the 1970s, is a structured peer-teaching framework in which students are responsible for mastering and teaching specific content areas (4). Broader evidence on active learning indicates that such approaches can enhance academic performance, accountability, and engagement, while also supporting motivation and positive learning attitudes (5).

With the growing emphasis on competency-based curricula that prioritize patient safety, increasing attention has been directed toward the development of clinical reasoning skills. This involves integrating clinical findings, systematically collecting relevant diagnostic data, and considering patient-related factors in decision-making across both discipline-specific and multidisciplinary dental contexts (6). This need is particularly pronounced in pediatric dentistry, where effective practice requires integrative thinking that combines child psychology, caries risk assessment, preventive strategies, minimally invasive dentistry, and effective communication with the child and parents. Students frequently report challenges in managing pediatric patient behavior, applying structured communication strategies, and synthesizing clinical data into coherent treatment plans (7). Evidence on dental fear and behavior management in pediatric dentistry underscores the important role of communication skills and psychological insight in training (8).

Despite growing interest in cooperative learning, evidence on the effectiveness of the Jigsaw technique within pediatric dentistry education remains limited. Existing dental education literature has examined instructional strategies aimed at problem-solving, critical thinking, and self-directed learning (9), but evidence specifically evaluating the Jigsaw method in pediatric dentistry using randomized designs and OSCE-based clinical reasoning outcomes remains limited. Contemporary conceptual frameworks in dental education emphasize experiential learning, discovery-based reasoning, and learner autonomy, reinforcing the value of evaluating structured cooperative models such as Jigsaw within specialized clinical contexts (10). With respect to assessment, objective methods such as the Objective Structured Clinical Examination (OSCE) can provide a reliable measure of clinical competence and help shift instructional strategies toward more practice-oriented educational interventions (11).

To our knowledge, randomized controlled trials evaluating the impact of Jigsaw learning methodology on diagnostic accuracy, clinical reasoning, and communication performance in pediatric dentistry remain scarce. This gap is significant given the growing emphasis on competency-based and patient-centered training advocated by major dental education bodies (12).

This study aimed to evaluate the effectiveness of a Jigsaw-based cooperative learning intervention, compared with traditional lecture-based instruction, in enhancing clinical reasoning, diagnostic accuracy, communication performance, and knowledge retention among undergraduate dental students in pediatric dentistry. The study is grounded in a health professions education framework and draws on pedagogical principles relevant across clinical disciplines, applied here within a pediatric dentistry context.

2. Materials and Methods

2.1 Study Design and Ethical Approval

This study was designed as a parallel-group randomized controlled trial with a mixed quantitative and qualitative approach, conducted within the undergraduate pediatric dentistry curriculum among fourth-year Bachelor of Dental Surgery (BDS) students at a Gulf-region dental school. The design and reporting adhered to the Consolidated Standards of Reporting Trials (CONSORT) guidelines adapted for educational interventions (13).

Ethical approval

was obtained from the Institutional Review Board (IRB), College of Dentistry, Gulf Medical University (Approval No. IRB/COD/FAC/71/MAR-2024; 23 March 2024). The study was classified as minimal-risk, non-interventional educational research. Written informed consent was obtained from all participants prior to enrollment. Participation was voluntary and had no bearing on students' academic evaluation.

2.2 Participants and Setting

All students enrolled in the pediatric dentistry course during the study period were eligible to participate, provided they attended at least 80% of scheduled course activities and had no prior formal exposure to the Jigsaw cooperative learning technique.

Students who did not complete either the pre-intervention or post-intervention assessments were excluded from the final analysis.

2.3 Sample Size Calculation

An a priori sample size estimation was performed using G*Power (Heinrich Heine University, Düsseldorf, Germany) for an independent-samples comparison of the primary outcome. Assuming a two-sided alpha level of 0.05, 80% power, and an anticipated effect size of approximately Cohen's d = 0.60, a minimum of

45 participants per group was required. To account for possible attrition, 100 students were invited to participate.

2.4 Randomization and Allocation Concealment

Participants were randomly assigned to either the Jigsaw-based cooperative learning intervention group or the control group using a computer-generated block randomization sequence. The sequence was generated independently, and block sizes were concealed to minimize the risk of allocation prediction.

Allocation concealment was maintained using sequentially numbered, opaque, sealed envelopes prepared by an independent administrative staff member who was not involved in participant recruitment, instruction, assessment, or data analysis.

2.5 Pre-Intervention Phase

To ensure standardization and reduce variability in delivery, all facilitators were trained before the study commenced. Training followed a standardized facilitation guide outlining session structure, timing, and interaction protocol, and was reinforced through a calibration meeting prior to implementation. Facilitators were explicitly instructed to maintain a process-facilitation role only, avoiding direct instruction, corrective feedback, or content supplementation that could influence learning outcomes.

2.6 Educational Intervention Group

Five fundamental domains of pediatric dentistry were identified in accordance with the American Academy of Pediatric Dentistry (AAPD) Reference Manual and undergraduate curriculum recommendations and used to structure four Jigsaw sessions, each lasting 60 minutes (14). These domains were caries risk assessment, preventive strategies, minimally invasive treatment planning, behavior guidance, and communication with parents.

The Jigsaw format was based on the original model described by Aronson (4). Students were first assigned to “expert groups,” in which each group focused on one domain using curated learning materials, including short readings, clinical images, and case vignettes. Facilitators ensured balanced participation and adherence to the allotted time.

Students subsequently returned to their “home groups,” where each member taught their assigned domain to peers. Home groups then integrated all domains to develop a comprehensive diagnostic assessment and treatment plan for a standardized pediatric case.

2.7 Control Group

The control group received the same learning objectives and content through traditional lecture-based, educator-centered instruction supplemented by whole-class discussion. Students were encouraged to participate in discussion, clarify key concepts, and identify areas of uncertainty.

To support standardization, instructional time and access to learning materials were equivalent between groups in order to minimize exposure bias. Faculty followed a standardized lecture guide to ensure consistency of delivery across sessions.

2.8 Outcome Variables and Measurement

Multiple outcomes were assessed using structured measurement tools aligned with the study objectives. Diagnostic accuracy was evaluated through an Objective Structured Clinical Examination (OSCE) based on a standardized pediatric case, using an analytic rubric covering diagnostic formulation, risk assessment, and treatment planning. The rubric drew on established OSCE frameworks used in dental education (11). Raw diagnostic accuracy scores were recorded on a 0–6 scale, derived from the average of two independent examiners' ratings; the averaged raw score was then converted to a 100-point percentage scale for analysis and reporting.

Clinical reasoning was assessed using an analytic rubric comprising three domains—data interpretation, hypothesis generation, and justification of clinical decisions—with predefined performance descriptors and a total score ranging from 0 to 40.

Communication performance was evaluated using a standardized parent-actor simulation with a structured scoring checklist. Students were assessed on clarity of explanation, empathy, and shared decision-making, using a checklist adapted from validated communication assessment tools in health professions education (15). Each domain was initially scored on a 0–5 rubric and, for analysis and reporting, multiplied by three to yield a 0–15 scale per domain and a total communication score ranging from 0 to 45. Standardized parent actors were trained to ensure consistency across encounters.

Knowledge acquisition and retention were measured using a multiple-choice test administered at three time points: pre-intervention, immediately post-intervention, and four weeks post-intervention. Items were developed in accordance with National Board of Medical Examiners guidelines for high-quality assessment design to ensure content validity and appropriate cognitive-level targeting (16).

A structured questionnaire comprising multiple Likert-scale items assessing engagement, perceived learning effectiveness, understanding of clinical concepts, and collaboration was used to capture learner perception. Two open-ended questions were also included. Responses were independently coded by two investigators and analyzed thematically until consensus on emerging themes was reached, in line with established qualitative methodology (17).

2.9 Bias Control

All OSCE assessments were independently scored by two trained examiners who were blinded to group allocation. A pilot reliability study was conducted in which the examiners scored 10 OSCE stations twice, with a one-week interval between assessments. Interrater and intrarater reliability were estimated using the intraclass correlation coefficient (ICC) and were 0.82 for diagnostic accuracy scoring and 0.79 for

communication performance. All student answer sheets were anonymized and coded to further minimize assessment bias.

2.10 Data Analysis

All quantitative data were coded, tabulated, and analyzed using IBM SPSS Statistics version 22. Descriptive statistics included means, standard deviations, frequencies, and percentages. Between-group comparisons were performed using independent-samples t-tests, consistent with the parallel-group randomized design. Statistical significance was set at $p < 0.05$.

Open-ended responses from the perception questionnaire were analyzed using thematic analysis. Two investigators independently coded the responses and resolved differences through iterative discussion until consensus on emerging themes was reached, consistent with established qualitative methodology (17).

3. Results

3.1 Participant Characteristics

A total of 100 fourth-year BDS students were assessed for eligibility and consented to participate. All participants met the predefined inclusion criteria and were randomly assigned to either the Jigsaw intervention group (n = 50) or the control group (n = 50). During the study period, two participants (one from each group) were excluded from the final analysis owing to incomplete post-intervention assessments. Consequently, the final analytic sample comprised 98 students, with 49 in the Jigsaw group and 49 in the control group. The participant flow is shown in Fig. 1.

3.2 Baseline Characteristics

Baseline demographic and academic characteristics were comparable between the two groups. The mean age was 22.1 ± 0.8 years in the Jigsaw group and 22.0 ± 0.9 years in the control group. Female students represented 61.2% of the Jigsaw group and 59.2% of the control group. Pre-intervention knowledge scores showed no statistically or clinically significant differences between groups, indicating successful baseline equivalence (Table 1).

Table 1
Baseline characteristics of participants

Characteristic	Jigsaw group (n = 49)	Control group (n = 49)	P value
Age, years (mean ± SD)	22.1 ± 0.8	22.0 ± 0.9	0.54
Female, n (%)	30 (61.2)	29 (59.2)	0.84
Pre-intervention knowledge score (mean ± SD)	61.5 ± 8.4	62.0 ± 8.1	0.73
Previous pediatric clinical exposure, n (%)	18 (36.7)	17 (34.7)	0.84

Independent-samples t-tests were used.

3.3 Quantitative Outcomes

3.3.1 Diagnostic Accuracy

Post-intervention OSCE-based diagnostic accuracy scores differed significantly between the two groups ($p < 0.001$), with a large effect size (Cohen's $d = 1.24$). The Jigsaw group achieved a higher mean diagnostic accuracy score (78.4 ± 6.2) than the control group (70.1 ± 7.0).

3.3.2 Clinical Reasoning

Clinical reasoning scores were significantly higher in the Jigsaw group than in the control group (32.6 ± 4.1 versus 27.9 ± 4.5, respectively; $p < 0.001$).

Table 2
Clinical reasoning assessment scores

Domain	Jigsaw group (mean ± SD)	Control group (mean ± SD)	P value
Data interpretation	10.9 ± 1.6	9.1 ± 1.8	< 0.001
Hypothesis generation	11.2 ± 1.5	9.4 ± 1.7	< 0.001
Justification of decisions	10.5 ± 1.4	9.4 ± 1.6	0.002
Total score	**32.6 ± 4.1**	**27.9 ± 4.5**	**< 0.001**

Independent-samples t-tests were used.

3.3.3 Communication Performance

Communication performance scores were significantly higher in the Jigsaw group (41.2 ± 5.3) than in the control group (35.8 ± 5.9) ($p < 0.001$). The largest between-group differences were observed in the clarity of explanation and shared decision-making domains.

Table 3
Communication performance scores in the standardized parent OSCE

Domain	Jigsaw group (mean ± SD)	Control group (mean ± SD)	P value
Clarity of explanation	14.2 ± 2.0	11.9 ± 2.3	< 0.001
Empathy	13.5 ± 1.9	12.6 ± 2.1	0.03
Shared decision-making	13.5 ± 2.1	11.3 ± 2.4	< 0.001
Total score	**41.2 ± 5.3**	**35.8 ± 5.9**	**< 0.001**

Independent-samples t-tests were used. Each domain score was transformed from a 0–5 raw rubric scale to a 0–15 scale by multiplying by 3 for analysis.

3.3.4 Knowledge Acquisition and Retention

Knowledge test scores increased from pre-intervention to immediate post-intervention assessment in both groups. In the Jigsaw group, mean knowledge scores rose from 61.5 ± 8.4 at baseline to 81.9 ± 7.1 immediately post-intervention and remained at 77.6 ± 7.8 at the four-week follow-up. In the control group, scores increased from 62.0 ± 8.1 to 74.3 ± 7.9 post-intervention and declined to 69.2 ± 8.5 at follow-up.

At the four-week assessment, knowledge retention was significantly higher in the Jigsaw group than in the control group (p = 0.002).

Table 4
Knowledge assessment scores at three time points

Time point	Jigsaw group (mean ± SD)	Control group (mean ± SD)	P value
Pre-intervention	61.5 ± 8.4	62.0 ± 8.1	0.73
Post-intervention	81.9 ± 7.1	74.3 ± 7.9	< 0.001
Four-week follow-up	77.6 ± 7.8	69.2 ± 8.5	0.002

Independent-samples t-tests were used.

3.3.5 Learner Perception

Post-intervention questionnaire responses indicated differences in learner perceptions of the instructional approach. Students in the Jigsaw group reported higher engagement (4.3 ± 0.5) than the control group (3.6 ± 0.6), and higher perceived learning effectiveness (4.2 ± 0.6 versus 3.5 ± 0.7).

Table 5
Learner perception questionnaire results

Item	Jigsaw group (mean ± SD)	Control group (mean ± SD)	P value
Engagement in learning	4.3 ± 0.5	3.6 ± 0.6	< 0.001
Perceived learning effectiveness	4.2 ± 0.6	3.5 ± 0.7	< 0.001
Understanding of pediatric concepts	4.4 ± 0.5	3.7 ± 0.6	< 0.001
Collaborative learning experience	4.5 ± 0.4	3.8 ± 0.6	< 0.001

Scores based on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree).

3.4 Qualitative Findings

Thematic analysis of open-ended questionnaire responses identified three main themes that reflected the student learning experience and provided contextual support for the quantitative results. Students reported that the Jigsaw cooperative learning model facilitated the integration of clinical concepts, enhanced their confidence in communicating treatment plans to parents, and reinforced the educational value of peer teaching for understanding complex pediatric dentistry topics.

Representative quotations illustrating each theme are presented in the qualitative summary table.

Table 6
Qualitative themes and representative student quotations

Theme	Description	Representative quotation
Integration of clinical concepts	Students described improved ability to connect diagnostic findings with treatment decisions	“Teaching my peers forced me to understand how diagnosis, prevention, and behavior management fit together.”
Confidence in parent communication	Students reported increased confidence when explaining treatment plans to parents	“I felt more confident explaining options to parents during the OSCE after practicing in the group.”
Value of peer teaching	Peer teaching was perceived as helpful for mastering complex topics	“Explaining the topic to others made it much clearer for me than listening to a lecture.”

4. Discussion

This randomized controlled trial evaluated the impact of a Jigsaw-based cooperative learning intervention on several pediatric dentistry competencies using objective, performance-based

assessments. The study makes two main contributions: first, it provides discipline-specific evidence of improved acquisition of pediatric dentistry competencies; and second, it contributes methodologically by evaluating cooperative learning with standardized OSCE-based outcome measures rather than self-reported or descriptive evaluations, thereby strengthening the evidence base for active learning strategies in health professions education.

Fourth-year BDS students were selected intentionally, as this stage of training marks an early point at which clinical reasoning is integrated into pediatric dentistry education. At this level, students begin to translate theoretical knowledge into structured clinical reasoning across competencies such as caries risk assessment, behavior guidance, preventive decision-making, and structured communication with parents. Standard pediatric dentistry textbooks and curricular frameworks identify this stage as a critical transition from theoretical knowledge acquisition to case-based clinical reasoning and decision-making (14, 18).

The findings indicate that students who received the Jigsaw intervention achieved higher performance in OSCE-based diagnostic accuracy, clinical reasoning, communication performance, and knowledge retention than those who received traditional lecture-based instruction. These results should be interpreted as evidence of effectiveness within a defined educational and institutional context rather than as definitive support for broad curriculum replacement.

The findings suggest that structured peer teaching may support the development of integrated clinical competencies central to pediatric dental practice. Improvements were observed in domains extending beyond factual knowledge, including clinical reasoning and communication performance assessed through standardized OSCE encounters (11). The use of objective, standardized outcome measures strengthens the interpretation of these findings and aligns with current expectations for rigor in health professions education research.

The observed improvements in clinical reasoning and diagnostic accuracy are consistent with constructivist learning theory, which emphasizes active knowledge construction through engagement, explanation, and social interaction (19). Within the Jigsaw framework, students must not only understand assigned content but also master and subsequently teach it to peers, a process that may promote elaborative and deeper cognitive processing and support conceptual integration (20). These mechanisms may help explain the higher reasoning performance observed in the intervention group; however, they were not directly measured in this study and should therefore be regarded as theoretical rather than empirically established.

The present findings are consistent with evidence supporting cooperative learning in education, where improved academic performance and learner engagement have been reported (2). Previous dental education literature has emphasized instructional strategies for problem-solving, critical thinking, and self-directed learning, but less often through randomized OSCE-based evaluation of a specific cooperative learning intervention (9). By contrast, the present study strengthens this evidence base

through a randomized design and OSCE-based evaluation, thereby extending existing literature and addressing a recognized methodological gap.

A notable feature of the study is the relatively large effect sizes observed across several outcomes, particularly diagnostic accuracy and clinical reasoning. Although these findings are promising, they should be interpreted cautiously. Several factors may have contributed to the magnitude of these effects, including novelty and engagement effects, alignment between the intervention and the assessment methods, enhanced learner motivation within the peer-teaching environment, and a short-term intervention with immediate performance gains. These factors should be considered when interpreting the results.

Students in the Jigsaw group demonstrated significantly higher communication performance during standardized parent encounters. Effective communication with parents is a core competency in pediatric dentistry and is important for behavior management, treatment acceptance, and patient-centered care (15). The structured peer interaction and collaborative discussion inherent in the Jigsaw approach provide a low-risk environment that may facilitate rehearsal and refinement of communication strategies, contributing to improved performance in simulated encounters. It is important to acknowledge, however, that the simulated nature of OSCE-based communication assessment may not fully capture the complexity of real clinical scenarios.

Although both instructional approaches were associated with short-term improvements in knowledge scores, the Jigsaw group showed superior knowledge retention at the four-week follow-up. This finding is consistent with literature highlighting the role of active learning strategies in enhancing long-term retention through elaborative processing and retrieval practice (21). Assessment-driven learning theory further suggests that assessment formats influence learning strategies and retention; alignment between the Jigsaw intervention and OSCE-based assessment may therefore have encouraged deeper learning approaches and contributed to sustained retention. The limitation of the follow-up period to four weeks may restrict conclusions about longer-term retention.

Faculty facilitation played an important role in guiding group activities. Although facilitators were trained before implementation and followed a standardized protocol to minimize variability across groups, subtle differences in facilitation style and communication may still have influenced student engagement and outcomes.

From an educational evaluation perspective, these findings support integrating structured cooperative learning strategies into pediatric dentistry curricula to foster integrated cognitive and interpersonal competencies. The study also demonstrates the feasibility of implementing the Jigsaw model within existing curricular structures without increasing instructional time.

This study highlights the value of the OSCE as a rigorous assessment tool for evaluating educational interventions targeting clinical reasoning and interpersonal skills (11). Nevertheless, simulation-based assessment should ideally be complemented by more complex, workplace-based evaluation.

Beyond pediatric dentistry, these findings may inform instructional design and assessment strategies across health professions education programs that emphasize collaborative learning and competency-based assessment. However, contextual factors such as class size, institutional culture, and facilitator expertise are likely to influence the impact of such approaches.

The qualitative findings provide supportive, but not confirmatory, evidence of the intervention's effectiveness. These perceptions are consistent with the quantitative results; however, they should be interpreted as contextual insights that enrich understanding of the learning experience rather than as independent validation of effectiveness.

Several limitations should be acknowledged. This was a single-center study, which may limit generalizability. Although outcome assessors were blinded, participant blinding was not possible given the nature of the intervention. Performance in simulated settings may not fully reflect real clinical scenarios. In addition, potential between-group differences cannot be fully excluded, although separate scheduling and instructional materials were used to minimize this risk.

The strengths of this study include the use of a randomized design and objective assessments, which support the validity of the findings, and the application of a Jigsaw model previously described within dental and health professions education. Future research should examine longer-term outcomes, performance in authentic clinical settings, and interactions between cooperative learning and learner characteristics.

5. Conclusion

Within the limitations of this study, the present randomized controlled study provides evidence that a structured Jigsaw-based cooperative learning intervention can improve clinical reasoning, diagnostic accuracy, communication performance, and knowledge retention compared with traditional lecture-based instruction. Consistent with contemporary competency-based education frameworks, the findings suggest that combining peer teaching with objective performance-based assessment may support stronger learning outcomes.

Beyond this specific disciplinary context, the findings highlight the value of OSCEs and standardized communication tasks for evaluating learner-centered instructional designs. These conclusions apply within the studied educational setting and should not be interpreted as evidence of broad curriculum superiority or of direct transfer to clinical practice.

Future research should explore the transferability of Jigsaw-based models across disciplines, incorporate longer-term evaluation that includes complex clinical performance, and examine their role within programmatic assessment systems in health professions education.

Declarations

Ethics approval and consent to participate

This study was reviewed and approved by the Institutional Review Board (IRB), College of Dentistry, Gulf Medical University (Ref. No. IRB/COD/FAC/71/MAR-2024, 23 March 2024). All methods were performed in accordance with the relevant guidelines and regulations of the Institutional Review Board (IRB), College of Dentistry, Gulf Medical University, and with the principles of the Declaration of Helsinki. All participants provided written informed consent prior to participation. Participation was voluntary, and students were informed that their decision to participate or withdraw would not affect their academic evaluation or standing.

Consent for publication

Not applicable. No individual participant data, images, or identifiable information are included in this manuscript.

Conflict of interest
No potential conflict of interest relevant to this article was reported.

Funding
None.

Data availability

The datasets generated and/or analyzed during the current study are not publicly available due to participant confidentiality and institutional data protection requirements but are available from the corresponding author on reasonable request.

Acknowledgments
None.

AI Disclosure:

AI tools were used for language refinement and editorial support. All scientific content, data analysis, interpretation, and conclusions were independently reviewed and verified by the authors.

References

1. Prince M. Does active learning work? A review of the research. J Eng Educ. 2004;93:223–31.
2. Johnson DW, Johnson RT, Smith KA. Cooperative learning: improving university instruction by basing practice on validated theory. J Excell Coll Teach. 2014;25:85–118.
3. Michaelsen LK, Sweet M, Parmelee DX. Team-based learning: small group learning's next big step. New Dir Teach Learn. 2008;116:7–27.

4. Aronson E, Blaney N, Stephan C, Sikes J, Snapp M. The Jigsaw Classroom. Beverly Hills (CA): Sage; 1978.
5. Freeman S, Eddy SL, McDonough M, Smith MK, Okoroafor N, Jordt H, Wenderoth MP. Active learning increases student performance in science, engineering, and mathematics. Proc Natl Acad Sci U S A. 2014;111:8410–5.
6. Norman G. Research in clinical reasoning: past history and current trends. Med Educ. 2005;39:418–27.
7. Zafar S, Siddiqi A. Pediatric dentistry training and perceived preparedness of undergraduate dental students. Eur J Dent Educ. 2018;22:e310–6.
8. Klingberg G, Broberg AG. Dental fear/anxiety and dental behaviour management problems in children and adolescents. Int J Paediatr Dent. 2007;17:391–406.
9. Hendricson WD, Andrieu SC, Chadwick DG, Chmar JE, Cole JR, George MC, et al. Educational strategies associated with development of problem-solving, critical thinking, and self-directed learning. J Dent Educ. 2006;70:925–36.
10. Formicola AJ, Myers R, Hasler JF, et al. Evolution of dental education. J Dent Educ. 2017;81:eS16–23.
11. Harden RM, Gleeson FA. Assessment of clinical competence using an objective structured clinical examination (OSCE). Med Educ. 1979;13:41–54.
12. Commission on Dental Accreditation. Accreditation Standards for Dental Education Programs. CODA; 2020.
13. Schulz KF, Altman DG, Moher D. CONSORT 2010 statement. BMJ. 2010;340:c332.
14. American Academy of Pediatric Dentistry. Reference Manual of Pediatric Dentistry. Chicago (IL): AAPD; 2023.
15. Silverman J, Kurtz S, Draper J. Skills for Communicating with Patients. 3rd ed. Radcliffe Publishing; 2013.
16. Case SM, Swanson DB. Constructing Written Test Questions for the Basic and Clinical Sciences. 4th ed. Philadelphia (PA): National Board of Medical Examiners; 2016.
17. Braun V, Clarke V. Using thematic analysis in psychology. Qual Res Psychol. 2006;3:77–101.
18. Nowak AJ, Christensen JR, Mabry TR, Townsend JA, Wells MH. Pediatric Dentistry: Infancy through Adolescence. 6th ed. Elsevier; 2019.
19. Bransford JD, Brown AL, Cocking RR. How People Learn: Brain, Mind, Experience, and School. Washington (DC): National Academy; 2000.
20. Chi MTH. Active-constructive-interactive: a conceptual framework for differentiating learning activities. Top Cogn Sci. 2009;1:73–105.
21. Dunlosky J, Rawson KA, Marsh EJ, Nathan MJ, Willingham DT. Improving students' learning with effective learning techniques. Psychol Sci Public Interest. 2013;14:4–58.

Figures

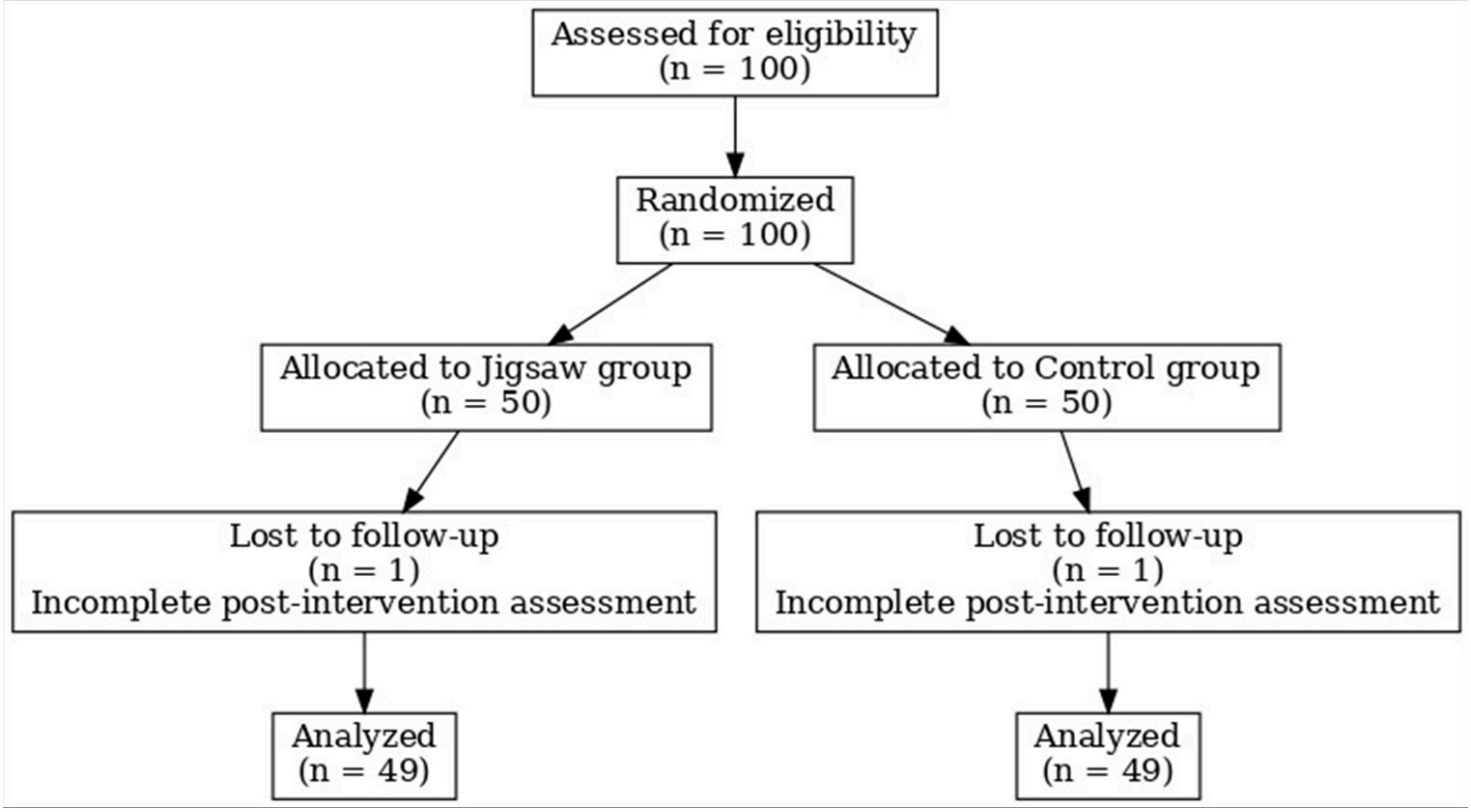


Figure 1

CONSORT flow diagram of participant recruitment, randomization, allocation, follow-up, and analysis. Fourth-year Bachelor of Dental Surgery students were assessed for eligibility and randomly allocated to either a Jigsaw-based cooperative learning group or a traditional lecture-based control group. Participants were followed through post-intervention assessment and final analysis. Numbers of participants at each stage and reasons for exclusion or loss to follow-up are shown.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementarymaterialslegend.docx
- FINALSupplementaryFile1JigsawInterventionDescription.docx
- FINALSupplementaryFile2OSCERubricsExaminerInstructions.docx
- FINALSupplementaryFile4CONSORTChecklist.docx
- FINALSupplementaryFile3LearnerPerceptionQuestionnaireCoding.docx