Research Square

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Jigsaw Teaching Method and Traditional Teaching in Dental Education: An Intervention Study

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Research Article

Keywords: Jigsaw Method, Lecture-Based Learning, Active Learning, Education, Dentistry

Posted Date: November 1st, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11236033/v1

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Additional Declarations: No competing interests reported.

Abstract

Background:

Jigsaw is a cooperative learning method grounded in the collaborative construction of knowledge, based on breaking down complex content into smaller segments, similar to the pieces of a “jigsaw puzzle”. This study was an educational intervention that aimed to compare the active Jigsaw methodology with the traditional teaching method (lecture-based learning) in terms of academic performance, satisfaction, and feedback among dental students.

Methods:

This educational intervention study included dental students enrolled in Cariology (5th semester) and Preclinical Pediatric Dentistry (8th semester) at Atitus University, Passo Fundo, Brazil. Five classes were allocated to Jigsaw or traditional lecture-based teaching through class-level randomization. Both methods addressed the same learning objectives and content and had the same total duration, and both were implemented by the same trained instructor. Academic performance (primary outcome) was assessed using five multiple-choice questions; satisfaction (second outcome) using a Likert scale; and immediate feedback (second outcome) using six structured items. Descriptive statistics and logistic regression analyses were performed using STATA 18.0.

Results:

The final sample included 112 students, 77.06% of whom were female. No statistically significant differences were found between the Jigsaw and traditional lecture-based groups in academic performance, immediate feedback (all $p > 0.05$), or student satisfaction (over 89% satisfaction for both groups; $p = 0.407$).

Conclusions:

Under the conditions investigated, Jigsaw did not demonstrate statistically significant advantages over traditional lecture-based teaching in academic performance, student satisfaction, or immediate feedback.

Introduction

For a long time, lecture-based learning has been the basis of the educational system in Dentistry and has traditionally been an effective teaching-learning strategy. Traditional didactic lectures are useful for knowledge transmission; however, they may limit learning focused on student interaction and immersion [1–3]. With the advancement of the digital era, changes had to be made to the educational system,

teaching methods, and learning resources [1]; in addition to clinical competencies, healthcare students must develop effective communication, cooperation, and critical thinking skills during their education [1].

Jigsaw is a group-based learning method grounded in collaboration among students. This approach is primarily based on student cooperation and active discussion of the content rather than solely on lectures and explanations provided by teachers. It promotes active listening, respect, and collaboration among students, while also encouraging critical thinking and responsibility for their own learning. This self-directed learning process facilitates concept development, greater academic productivity, and better knowledge retention [2,4].

Previous studies have demonstrated that, when the focus changes from the individual to the group, individual learning tends to be enhanced rather than reduced, allowing a group of students to address multiple topics simultaneously within a specific time frame [2,3,5]. Therefore, using a student-centered cooperative learning approach enables students to work as a team in a mutually interdependent way.

Although active learning methodologies have been increasingly incorporated into health professions education, evidence directly comparing Jigsaw cooperative learning with traditional lecture-based teaching in undergraduate dental education remains limited. Studies evaluating these approaches within the same institutional context, using the same instructor and comparable learning objectives, may help clarify whether Jigsaw offers measurable advantages over conventional teaching in terms of student satisfaction, perceptions of the teaching-learning process, and academic performance. Comparing these teaching methods across different stages of the dental curriculum may provide valuable insights into their applicability in undergraduate education and inform the implementation of active learning strategies.

Therefore, the aim of this study was to compare the Jigsaw active methodology and traditional lecture-based teaching in terms of academic performance, satisfaction, and immediate feedback among dental students. The primary research question was whether students exposed to Jigsaw would demonstrate better academic performance, report higher satisfaction, provide more favorable feedback regarding the teaching-learning process than students exposed to traditional lecture-based teaching. We hypothesized that the Jigsaw methodology would be associated with more favorable student perceptions and better academic performance than the traditional approach.

Methods

Study design

This was a parallel educational intervention study involving dental students from a private university in southern Brazil.

Participants

A convenience sample consisted of undergraduate Dentistry students at Atitus University, located in the city of *Passo Fundo, Rio Grande do Sul*, Brazil. Passo Fundo is a medium-sized city in the *Planalto Médio* region, in northern *Rio Grande do Sul*, Brazil. It is an important regional hub for health, education, and agriculture (*Instituto Brasileiro de Geografia e Estatística)* [6].

The students were regularly enrolled in the theoretical courses in Cariology and Preclinical Pediatric Dentistry in the Dentistry program during the first and second semesters of 2025.

Although Atitus University promotes and encourages the use of active learning methodologies in its various academic programs, dental students had not yet participated in classes taught using the Jigsaw methodology, underscoring the importance of this study in terms of student satisfaction and performance.

Eligibility criteria

The inclusion criteria comprised all students regularly enrolled in and attending the Cariology (5th semester) and Preclinical Pediatric Dentistry (8th semester) courses in the Dentistry program at Atitus University, Santa Teresinha Campus, located in *Passo Fundo, Rio Grande do Sul*. Exclusion criteria included students who did not attend the activities on the scheduled day or who did not attend or participate in the proposed educational activities.

Intervention

The study was conducted through the application of the active Jigsaw method and the traditional lecture-based teaching method in the classroom, in different classes, but covering the same topic. The study included five classes from two undergraduate Dentistry courses: Cariology (5th semester) and Preclinical Pediatric Dentistry (8th semester). The classes were randomly allocated to one of two teaching methods. Three classes were assigned to the traditional lecture-based teaching method, while the remaining two classes received the Jigsaw active learning methodology. An experienced professor in the field applied both teaching methods, and the classes had the same duration (3 hours). The professor received training in the teaching methods for the selected topics before leading the session, to ensure uniformity and reduce possible variations in teaching quality or instructor bias [1]. The teaching intervention was delivered according to the method assigned to each class. Both teaching methods were implemented using the same learning objectives, instructional content, and total instructional time. The main difference between the groups was the instructional approach: the Jigsaw group engaged in structured cooperative learning through individual preparation, expert-group discussions, and peer teaching, whereas the traditional group received content through the lecture-based approach. In both groups, the instructor explained the procedures and provided clarification when necessary.

The traditional lecture-based teaching method consisted of a 3-hour lecture in which the theoretical content was presented using slides and multimedia resources. The session followed a teacher-centered

approach, with the instructor delivering the content and students listening to the explanations. The same learning objectives and content coverage were maintained as in the Jigsaw intervention [7,8].

The Jigsaw teaching method is a cooperative learning strategy in which students work collaboratively to develop knowledge and share responsibility for learning [9]. The instructional content is divided into interconnected sections, and students become responsible for studying and subsequently teaching one section to their peers. The intervention in the present study consisted of three sequential phases: base-group formation, expert-group discussion, and return to the base groups. The instructor explained the procedures and expectations at the beginning of the activity and guided all phases, clarifying questions and ensuring that students understood how to carry out each stage.

In the first phase, students were organized into four base groups, with the group structure corresponding to the four sections into which the instructional content was divided. Printed learning materials were distributed among the students, with each student receiving a specific section identified by a letter (1, 2, 3, or 4). Students individually reviewed their assigned sections, focusing on understanding the key concepts that they would subsequently explain to their peers. In the second phase, students moved into expert groups, bringing together students who had been assigned the same section of the material. Within these groups, students discussed the assigned content, clarified questions, and developed a shared understanding of the main concepts. In the third phase, students returned to their original base groups. Each student explained their assigned section to the other group members, allowing the group to integrate the different sections into a broader understanding of the instructional content. Through peer teaching and collaborative discussion, students had the opportunity to clarify concepts and address remaining questions [10].

Figure 1 illustrates the step-by-step sequence of the Jigsaw active learning methodology.

Variables and Outcomes

The primary outcome of this study was academic performance, and secondary outcomes were satisfaction and immediate feedback on the activities performed. The instruments were adapted from previously published studies.

Academic performance was assessed using five multiple-choice questions developed to cover the content addressed during the teaching sessions. The same questions were administered to students in both the Jigsaw and traditional lecture-based groups to ensure consistency in the assessment instrument. Each question was scored dichotomously as correct or incorrect. Individual-item performance was expressed as the number and percentage of correct responses in each group, and the response distributions were compared between the teaching methods. The assessment focused on immediate academic performance. The students were informed and instructed on how to complete the activity and were given a time limit to respond. The questions were reviewed by faculty members with expertise in the subject area before administration; however, no formal validation study was conducted.

The questions covered the content presented to analyze each student's level of understanding of the concepts addressed in the teaching methods [11].

Satisfaction was assessed using the following question: "What is your level of satisfaction with this class?", with the response options "completely satisfied," "satisfied," "neither satisfied nor dissatisfied," "dissatisfied," and "completely dissatisfied." [12].

The data collection procedure included an immediate feedback questionnaire with six questions adapted from the previous literature to assess students' preferences. The questions addressed: clarity, understanding, comprehensiveness of the topic, opportunities for clarification of doubts, improvement of communication skills, stimulation of debate, the role of the educator, and applicability to other topics [1]. The feedback items applied to the students involved the following statements: 1) The active learning/lecture method used was able to provide a variety of teaching materials and activities to develop my teaching-learning process; 2) The way my professor taught through the active learning/lecture method was appropriate for the way I learn; 3) The professor used clear and relevant language; 4) The active learning/lecture method allowed the acquisition of knowledge and cognitive skills; 5) The active learning/lecture method promoted interaction and participation within the group; 6) The use of active learning/lecture methods improves my academic performance and engagement with my peers [13]. The responses ranged from "strongly disagree," "partially disagree," "neither agree nor disagree," "partially agree," and "strongly agree."

Sample size

The sample size calculation was performed using G*Power version 3.1.9.4 and was based on the outcome of academic performance, measured as a continuous variable. The calculation used the t-test family to compare the means of two independent groups, assuming an effect size of 0.5, a significance level of 5%, statistical power of 80%, and a 1:1 allocation ratio. The resulting minimum sample size was 102 students, with 51 participants per group.

Randomization

Randomization was performed at the class level, with each class constituting an allocation unit. Students were assessed individually, whereas the teaching intervention was allocated at the class level. In addition, students were not informed in advance of the teaching method assigned to their class. The classes were randomly allocated using simple randomization through sealed envelopes prepared and drawn by a person who was not involved in the research. The envelopes were opened at the time of class allocation to the teaching methods. The instructor was unaware of the allocation before delivering the first class and learned the assigned method for the subsequent class only after the first class had been conducted. Because the instructor was responsible for implementing both teaching methods, blinding during intervention delivery was not feasible.

Statistical analysis

Descriptive analysis of the data was performed using absolute frequencies and percentages. Logistic regression was used to compare categorical outcomes between the traditional lecture-based and active Jigsaw groups, with results reported as odds ratios (ORs) and 95% confidence intervals (CIs). A p-value < 0.05 was considered statistically significant. The analyses were performed using STATA statistical software, version 18.0.

Ethical Considerations

This study was approved by the Research Ethics Committee of Atitus University (CAAE 86555525.0.0000.5319). All participants in this study provided consent and signed the Informed Consent Form.

Use of generative artificial intelligence

ChatGPT (OpenAI) was used during the preparation of this manuscript to assist with English-language translation, grammatical and linguistic editing, manuscript organization, reference formatting, and figure preparation and editing. The authors reviewed and verified all content generated or modified with the assistance of the tool and remain fully responsible for the accuracy, integrity, and final content of the manuscript.

Results

The participant flowchart is presented in Fig. 2, showing the process of eligibility, randomization, allocation, final analysis, and losses to follow-up.

Figure 2. Flowchart of the study participants.

The descriptive analysis of the comparison between lecture-based learning and the Jigsaw method is presented in Table 1. The final sample consisted of 112 students. Regarding gender, 109 valid responses were obtained, with a predominance of female students (84; 77.06%), while 25 participants (22.94%) were male. Three students did not provide information for this question.

Table 1
Descriptive analysis and logistic regression of lecture-based learning, Jigsaw, and variables (n = 112)

Variables	Lecture-based learning n (%)	Jigsaw n (%)	OR (95% IC)	p-value
Performance – Question 1				0.327
Incorrect	27 (56.25)	30 (46.88)	1	
Correct	21 (43.75)	34 (53.12)	1.45 (0.68–3.09)	
Performance – Question 2				0.512
Incorrect	27 (56.25)	32 (50.00)	1	
Correct	21 (43.75)	32 (50.00)	1.28 (0.60–2.72)	
Performance – Question 3[#]				0.808
Incorrect	14 (31.11)	21 (33.33)	1	
Correct	31 (68.89)	42 (66.67)	0.90 (0.39–2.05)	
Performance – Question 4				0.314
Incorrect	21 (43.75)	22 (34.38)	1	
Correct	27 (56.25)	42 (65.62)	1.48 (0.68–3.20)	
Performance – Question 5				0.431
Incorrect	16 (33.33)	26 (40.62)	1	
Correct	32 (66.67)	38 (59.38)	0.73 (0.33–1.59)	
Satisfaction				

[#] Missing data.

- unanswered questions

OR: Odds Ratio. CI: Confidence interval.

Variables	Lecture-based learning n (%)	Jigsaw n (%)	OR (95% IC)	p-value
Completely satisfied	26 (54.17)	24 (37.50)	1	
Satisfied	17 (35.42)	33 (51.56)	2.10 (0.93–4.70)	0.071
Neither satisfied nor dissatisfied	2 (4.17)	4 (6.25)	2.16 (0.36–12.92)	0.396
Dissatisfied	1 (2.08)	1 (1.56)	1.08 (0.06–18.29)	0.956
Completely dissatisfied	2 (4.17)	2 (3.12)	1.08 (0.14–8.30)	0.939
Teaching learning-process				
Strongly disagree	-	-	-	
Partially disagree	3 (6.25)	3 (4.69)	2 (0.11–35.80)	0.638
Neither agree nor disagree	1 (2.08)	2 (3.12)	1.57 (0.27–8.90)	0.610
Partially agree	14 (29.17)	22 (34.38)	1.23 (0.23–6.55)	0.806
Strongly agree	30 (62.50)	37 (57.81)	1	
Learning approach[#]				
Strongly disagree	1 (2.08)	1 (1.59)	3.99 (0.11-136.95)	0.442
Partially disagree	1 (2.08)	4 (6.35)	0.66 (0.02–18.05)	0.810
Neither agree nor disagree	3 (6.25)	2 (3.17)	1.53 (0.08–26.43)	0.769
Partially agree	15 (31.25)	23 (36.51)	1.17 (0.07–19.71)	0.909
Strongly agree	28 (58.33)	33 (52.38)	1	

[#] Missing data.

- unanswered questions

OR: Odds Ratio. CI: Confidence interval.

Variables	Lecture-based learning n (%)	Jigsaw n (%)	OR (95% IC)	p-value
Use of clear and relevant language				
Strongly disagree	-	-	-	
Partially disagree	-	-	-	
Neither agree nor disagree	1 (2.08)	1 (1.56)	1.5 (0.07–31.57)	0.794
Partially agree	4 (8.33)	6 (9.38)	1.32 (0.08–21.79)	0.844
Strongly agree	43 (89.58)	57 (89.06)	1	
Knowledge acquisition and cognitive skills[#]				
Strongly disagree	-	-	-	
Partially disagree	3 (6.38)	4 (6.25)	1.5 (0.15–14.42)	0.725
Neither agree nor disagree	2 (4.26)	4 (6.25)	1.31 (0.25–6.87)	0.748
Partially agree	12 (25.53)	21 (32.81)	0.87 (0.18–4.22)	0.868
Strongly agree	30 (63.83)	35 (54.69)	1	
Class interaction and participation[#]				
Strongly disagree	1 (2.08)	2 (3.17)	0.12 (0.00-3.22)	0.210
Partially disagree	4 (8.33)	1 (1.59)	1.25 (0.07–22.87)	0.880
Neither agree nor disagree	2 (4.17)	5 (7.94)	0.54 (0.05–6.48)	0.633
Partially agree	21 (43.75)	23 (36.51)	0.80 (0.06–9.40)	0.859
[#] Missing data.				
- unanswered questions				
OR: Odds Ratio. CI: Confidence interval.				

Variables	Lecture-based learning n (%)	Jigsaw n (%)	OR (95% IC)	p-value
Strongly agree	20 (41.67)	32 (50.79)	1	
Perfomance and engagement [#]				
Strongly disagree	2 (4.35)	1 (1.59)	12.00 (0.71-203-13)	0.085
Partially disagree	2 (4.35)	12 (19.05)	2.00 (0.12–31.97)	0.624
Neither agree nor disagree	4 (8.70)	4 (6.35)	1.87 (0.15–22.88)	0.622
Partially agree	16 (34.78)	15 (23.81)	2.81 (0.24–33.04)	0.409
Strongly agree	22 (47.83)	31 (49.21)	1	
[#] Missing data.				
- unanswered questions				
OR: Odds Ratio. CI: Confidence interval.				

The findings on academic performance in the assessment questions indicate that no statistically significant differences were observed between the groups that participated in lecture-based learning and those who underwent the Jigsaw methodology ($p > 0.05$). In question 1, 43.75% of the correct answers occurred in the lecture-based learning group and 53.12% in the Jigsaw group ($p = 0.327$). In question 2, the percentages were 43.75% and 50.00%, respectively ($p = 0.512$). In question 3, the correct answers obtained were 68.89% for the lecture-based learning group, while for the Jigsaw group they were 66.67% ($p = 0.808$). In question 4, the percentage of correct answers was 56.25% and 65.62% ($p = 0.314$), respectively. In question 5, the percentages were 66.67% and 59.38% ($p = 0.431$).

In the satisfaction survey, among the students who received lecture-based learning, 26 (54.17%) reported being completely satisfied, and 17 (35.42%) reported being satisfied. In the Jigsaw group, among the students who received the active methodology, 24 (37.50%) reported being completely satisfied, and 33 (51.56%) reported being satisfied. No statistically significant difference was observed between the methodologies evaluated ($p > 0.05$).

In the teaching-learning process, 30 (62.50%) students in the lecture-based learning group and 37 (57.81%) in the Jigsaw group strongly agreed with the statement assessed. As for how students learn, 28 (58.33%) students in the lecture-based learning group and 33 (52.38%) in the Jigsaw group reported strongly agreeing. Regarding the use of clear and relevant language, 43 (89.58%) students in the lecture-

based learning group and 57 (89.06%) in the Jigsaw group strongly agreed with the statement. In terms of the acquisition of knowledge and cognitive skills, 30 (63.83%) students in the lecture-based learning group and 35 (54.69%) in the Jigsaw group strongly agreed. For class interaction and participation, 20 (41.67%) students in the lecture-based learning group and 32 (50.79%) in the Jigsaw group reported strongly agreeing. Finally, no statistically significant difference was observed between the groups in performance and engagement.

Discussion

The findings of this study contribute to expanding the evidence on the application of the Jigsaw learning method in dental education by directly comparing it with lecture-based learning at different stages of undergraduate education. The results provide relevant information on students' perceptions and receptiveness to different teaching methods, contributing to the planning of pedagogical practices that are more aligned with the characteristics and needs of different learning contexts. However, the absence of statistically significant differences should not be interpreted as evidence of equivalence. The study was not powered for equivalence, and the instruments were not validated in this population. The findings should be considered exploratory.

The results of this study differ from part of the literature investigating the Jigsaw methodology in health education. In a previous study, a significant improvement in academic motivation (mean 72.17, SD 12.42) was observed among those subjected to the Jigsaw methodology compared with the traditional method (mean 57.66, SD 11.87) [4]. Similarly, Shah et al. (2026) [14] reported an increase of 20.7% in students' performance after the application of the methodology, as well as positive perceptions related to learning, communication, and collaboration among students. Similar results were also described by Nimesh et al. (2025) [15], whose participants reported better understanding of the content (83.1%), clarification of doubts (76.1%), greater knowledge retention (77.5%), development of communication skills (83.1%), and high acceptance of the methodology (81.7%). In contrast, in the present study, no statistically significant differences were observed between the Jigsaw methodology and lecture-based learning, as these divergences may be related to methodological differences between the studies, including the study design, sample characteristics, application context, time of exposure to the methodology, and, particularly, students' familiarity with the Jigsaw method.

The predominance of female participants is a characteristic frequently reported in studies conducted with Dentistry students. This profile follows the trend of feminization observed in professional education and practice over recent decades [16]. Although the present study was not designed to investigate differences between genders, this distribution characterizes the sample evaluated and should be considered when interpreting the findings.

Nevertheless, the feedback revealed differences in students' receptiveness, suggesting that factors related to the stage of training and familiarity with the methodology may influence the learning experience. Students' perceptions suggest that receptiveness to the Jigsaw methodology varied

according to the stage of academic training. Among students in the early semesters, a greater preference for lecture-based learning was observed, as well as resistance to teamwork outside their usual circle and the need for content supplementation through a lecture at the end of the activities carried out during the application of the Jigsaw methodology. In contrast, students in the final years of the program reported greater satisfaction with the active learning methodology, highlighting that the activities favored participation, collaboration among peers, and learning, while lecture-based learning was associated with lower class engagement. These findings suggest that familiarity with active learning methodologies and the stage of academic training may influence acceptance of the Jigsaw methodology.

The present study has some limitations and potential biases that should be considered when interpreting the findings. Selection bias may have occurred due to the inclusion of students from a single educational institution and the assessment of only two undergraduate courses, which limits the generalizability of the results. To minimize this bias, data collection was conducted on different days and at different times during the academic term, attempting to include students from both daytime and evening classes at the educational institution. In addition, the administration of the questionnaires in a group setting may have favored information bias, although standardized instructions were provided and the anonymity of the responses was ensured. The self-reported satisfaction questionnaire provided relevant information on students' perceptions and engagement; however, it did not allow the objective measurement of the depth of learning or long-term knowledge retention. The content covered in the teaching methodologies was new to the students; however, no baseline knowledge assessment was conducted, which limits the ability to attribute post-intervention performance differences to the teaching methodology. In addition, the instruments were not formally validated in the target population, which limits the interpretation of the findings and may have reduced sensitivity to detect differences between methodologies. Blinding was not feasible because the instructor was responsible for delivering both teaching methods, and students could identify the teaching approach they experienced during the intervention. Although students were not informed of their class allocation in advance and the instructor was unaware of the allocation before the first class was delivered, awareness of the intervention during subsequent classes may have introduced expectancy or instructor-related bias. Another limitation of this study is that the original sample size calculation was based on individual students and did not account for the clustering of students within classes, while the teaching interventions were randomized at the class level. Although the study outcomes included categorical variables and ordinal responses, the calculation was used as an initial estimate for recruitment planning. A post hoc statistical power analysis was subsequently performed, yielding an estimated power of 100% for the observed data. Furthermore, only five classes were included, limiting the ability to reliably estimate between-class variability and account for clustering in the statistical analyses. Differences between the two courses may also have influenced the outcomes. These limitations should be considered when interpreting the findings, and future studies should incorporate cluster-based sample size calculations and recruit a larger number of classes to support more robust comparisons between teaching methods.

Several factors may help explain why Jigsaw did not demonstrate statistically significant advantages over traditional lecture-based instruction in the present study. Our main hypothesis is that students' limited familiarity with active learning methodologies and potential resistance to changes in established teaching and learning practices may have influenced the results. Students accustomed to teacher-centered instruction may initially experience difficulties adapting to a more collaborative and autonomous learning environment, in which they are expected to take greater responsibility for knowledge acquisition, explain concepts to peers, and actively participate in group discussions. This transition may require time, guidance, and repeated exposure before the potential benefits of cooperative learning become evident. In addition, the use of multiple-choice questions to assess academic performance may also have limited the detection of potential benefits related to deeper understanding, critical thinking, and collaborative knowledge construction, which may not be fully captured by this assessment format.

Therefore, future studies should investigate students' adaptation to cooperative learning over repeated exposures, evaluate the fidelity of implementation, and incorporate assessment methods capable of capturing both immediate academic performance and deeper learning outcomes. In addition, future research should include larger and more representative samples, encompassing students from different educational institutions to investigate the influence of receptiveness to the Jigsaw methodology. Finally, assessments after time intervals are recommended to investigate knowledge retention and the inclusion of faculty perceptions, in order to broaden the understanding of the effectiveness of the Jigsaw methodology in dental education.

Conclusion

The Jigsaw methodology and lecture-based learning showed no statistically significant differences in academic performance, student satisfaction, and immediate feedback in the present study. These findings suggest that further studies involving a larger number of classes and considering students’ familiarity with active learning methodologies are needed to better understand the potential contributions of Jigsaw to dental education.

Declarations

Ethics approval and consent to participate

This study was submitted to and approved by the Research Ethics Committee (REC) of Atitus University (approval number 86555525.0.0000.5319). All participants provided informed consent and signed the Informed Consent Form before participating in the study. The study was conducted in accordance with the ethical principles applicable to research involving human participants.

Consent for publication

Not applicable.

Availability of data and materials

The data generated and analyzed during the current study are not publicly available due to the confidentiality and privacy of the participants, as established in the informed consent process and the study's ethical requirements. However, the data may be requested upon justification to the corresponding author.

Competing interests

The authors declare no competing interests.

Funding

This study did not receive any specific funding.

Authors' contributions

Fernanda Ruffo Ortiz and Taigla Schneider designed this study and collected the data. Fernanda performed the statistical analysis. Taigla wrote the paper. Fernanda, Taigla, and Ticiane reviewed and approved the final version of the manuscript.

Acknowledgements

The authors would like to thank all students who participated in the study. The authors also thank Atitus University for its cooperation and support.

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Figures

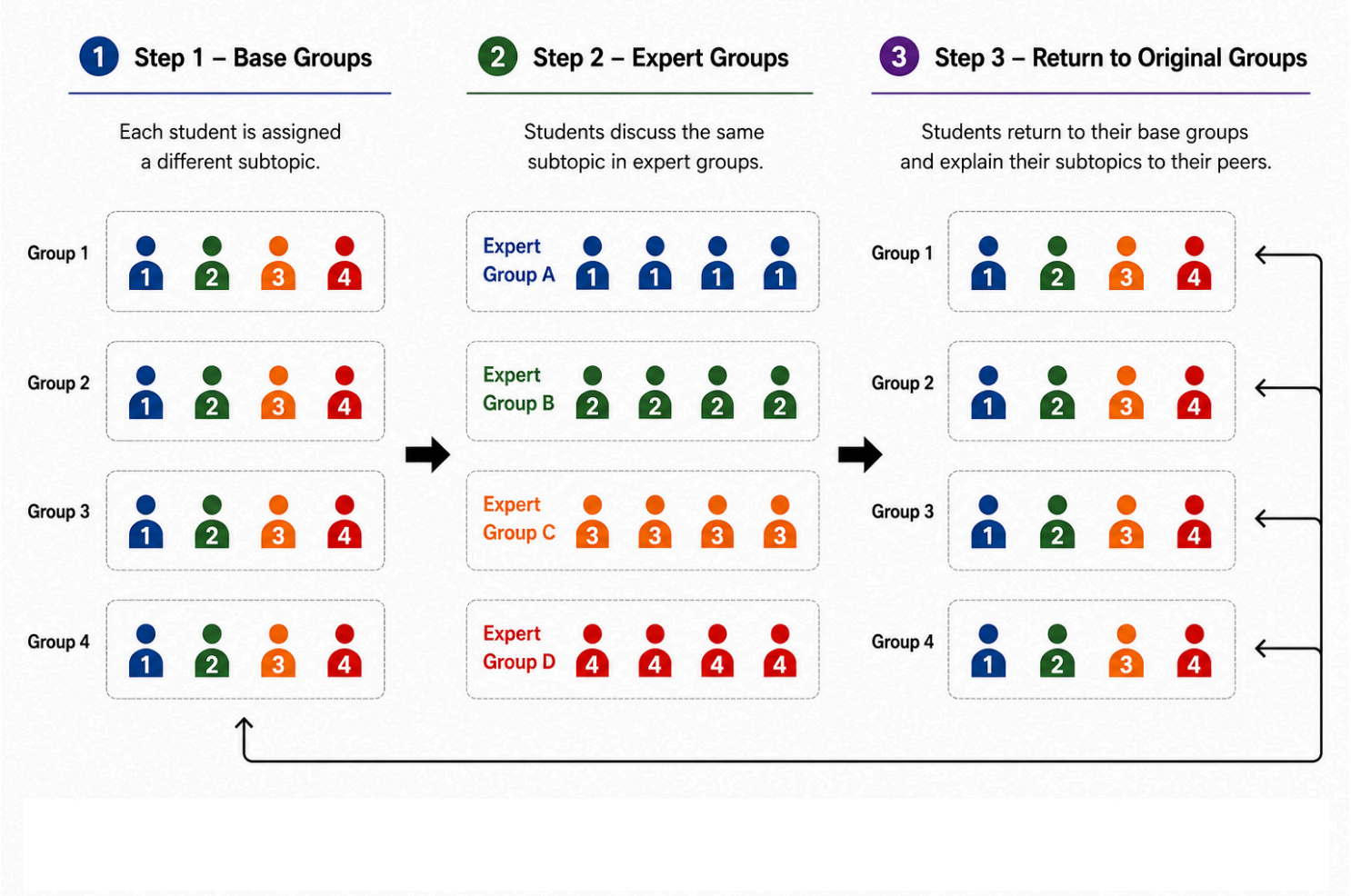


Figure 1

Schematic representation of the Jigsaw method.

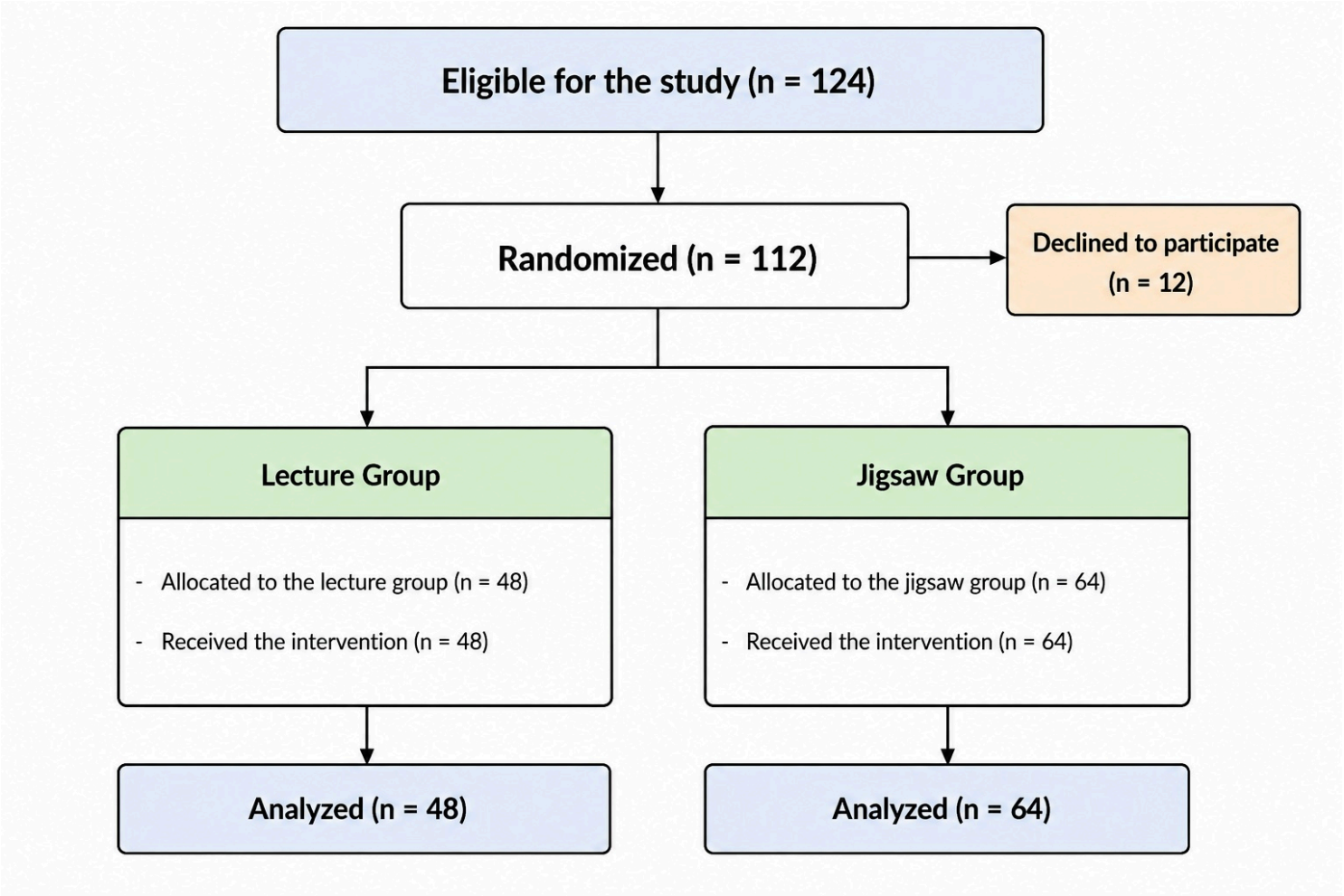


Figure 2

Flowchart of the study participants.