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Original Research Article

The power of peer learning: A prospective cross-over comparative study of Jigsaw versus Small Group Teaching in Pharmacology

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Abstract

Background: Active learning strategies such as cooperative learning are increasingly emphasized in modern medical education, particularly following the implementation of Competency-Based Medical Education (CBME) by the National Medical Commission (NMC) in India. This study compares the Jigsaw method, a structured cooperative learning technique, with Traditional Small Group Teaching (SGT) in enhancing the comprehension and long-term retention of pharmacology concepts among Phase-II medical students.
Materials and Methods: A prospective, crossover, interventional study was conducted with 60 Phase-II MBBS students randomly assigned to two groups. Two pharmacology topics (Calcium Homeostasis and Thyroid/Anti-Thyroid Drugs) were taught using both methods in a crossover design. Pre-test, immediate post-test, and 3-week retention tests were administered using MCQ-based assessments and open-ended questions. Statistical analysis was performed using independent and paired t-tests, Repeated Measures ANOVA, and descriptive statistics. Student and faculty feedback was collected via validated questionnaires the questionnaire used a 5-point Likert scale for assessment.
Results: The Jigsaw method resulted in significantly higher post-test and retention scores compared to SGT across both topics ($p<0.01$). Learning gains were greater in the Jigsaw group (+3.3 marks to +3.4 marks out of 15) than in the SGT group (+2.2 marks). The decline in retention was less pronounced in the Jigsaw group (mean difference -0.4 vs. -0.5 to -0.7 in SGT). Student feedback indicated that over 70% preferred the Jigsaw method, citing better peer communication, collaboration, and active involvement. Faculty reported higher student engagement with Jigsaw, though they noted it required more preparation time.
Conclusion: The Jigsaw technique is more effective than Traditional SGT in promoting both immediate learning and long-term retention of pharmacology knowledge. It also enhances students' engagement, collaboration, and peer-teaching skills. The implementation of the Jigsaw method is a viable and superior alternative in Pharmacology curricula to foster active, student-centred learning aligned with CBME competencies.

Keywords: Jigsaw method, Small group teaching, Pharmacology education, Active learning, Knowledge retention, Medical education, Cooperative learning

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1. Introduction

Medical education is undergoing a paradigm shift from teacher-centric to learner-centric approach, with an increasing emphasis on active learning and self-directed study.[1] This transition is particularly evident in the context of the Competency-Based Medical Education (CBME) curriculum implemented by the National Medical Commission (NMC) of India in 2019, which advocates for pedagogical strategies that enhance comprehension, retention, and clinical application of knowledge.[2]. Traditional didactic lectures, characterized by unidirectional dissemination of information, have been criticized for fostering passive learning and limiting opportunities for students to apply knowledge to real-life scenarios.[3,4] Cooperative learning methods, such as the Jigsaw technique and Small Group Teaching (SGT), have shown promise in fostering engagement, critical thinking, and teamwork among medical students.[5] These methods align with the principles of adult learning theory, which emphasize that learners benefit from active participation, relate to real-world contexts, and learn better given opportunities of self-direction.[1] Small-group teaching has been incorporated as a key instructional method in undergraduate medical education following the implementation of CBME, as it helps develop reasoning and problem-solving skills while exposing students to group

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dynamics that enable them to become confident practitioners.[2,6]

The Jigsaw method, developed by Aronson and Bridgeman in the 1970s, is a structured cooperative learning technique in which students become "experts" on specific subtopics before teaching their peers in small groups.[7] The process begins with the formation of "home groups," where each member is assigned a unique subtopic. Students then disperse to join "expert groups" consisting of individuals from different home groups who share the same subtopic. In these expert groups, students collaborate to master their assigned material through discussion, research, and mutual teaching. Finally, experts return to their home groups and take turns teaching their subtopics to their peers, effectively reconstructing the complete topic through collaborative learning.[8,9] This approach promotes active participation, peer instruction, and deeper cognitive processing, as students must not only understand their own subtopic but also effectively communicate it to others.

The theoretical foundation of the Jigsaw method rests upon Vygotsky's social constructivist theory, particularly the concept of the Zone of Proximal Development (ZPD).[10] According to this framework, learning occurs most effectively through social interaction and collaboration with more knowledgeable peers. In the Jigsaw classroom, the expert groups provide a medium for discourse and assisted learning, while the home groups create opportunities for peer teaching that reinforces understanding and identifies knowledge gaps.[11,12] The method also incorporates elements of positive interdependence and individual accountability, which are critical components of effective cooperative learning.[13]

In contrast, traditional Small Group Teaching (SGT) relies on facilitator-led discussions, where a teacher guides students through predetermined learning objectives, facilitates discussions, and clarifies concepts.[14] While SGT offers advantages over didactic lectures—including opportunities for interaction, clarification of doubts, and peer learning—it may not ensure equal participation or accountability among all group members.[15] Some students may remain passive observers while others dominate the discussion, and the facilitator's presence can sometimes inhibit free exchange of ideas.[16] Research on SGT implementation in Indian medical colleges has highlighted practical challenges, including large student-to-faculty ratios, infrastructure limitations, and the need for trained facilitators.[16,17] Despite these challenges, SGT remains a widely used instructional method, and studies have shown that students perceive it as more effective than lectures for understanding, engagement, and knowledge retention.[18]

Pharmacology education presents unique challenges due to the subject's complexity, vast scope, and extensive terminology.[19] Students must not only understand drug actions, interactions, therapeutic applications, and adverse effects but also retain and apply this knowledge in clinical settings.[20] Traditional teaching approaches in pharmacology have often relied on didactic lectures, which can hinder retention and application.[21] Recent research has explored various active learning strategies in pharmacology education, including spaced learning,[22] case-based learning,[23] and team-based learning,[24] with promising results for improving learning outcomes and student satisfaction.

Despite the recognized benefits of cooperative learning strategies, limited research directly compares the effectiveness of the Jigsaw method and Traditional SGT in pharmacology education, particularly in the Indian context, where CBME implementation has created an urgent need for evidence-based active learning strategies.[25] Studies have demonstrated the effectiveness of Jigsaw method in pharmacy education for teaching clinical pharmacokinetics,[26,27] medication therapy management,[28] and clinical controversies.[29] However, questions remain regarding its comparative effectiveness for knowledge retention, its applicability across different pharmacology topics, and its feasibility in resource-limited settings.

This study aims to fill this gap by evaluating the impact of both methods on learning outcomes, long-term retention, and student engagement among Phase-II MBBS students studying pharmacology. The specific objectives were: (1) to compare immediate knowledge acquisition between Jigsaw and SGT methods, (2) to assess knowledge retention at three weeks post-intervention, (3) to evaluate student perceptions and preferences regarding both methods, and (4) to gather faculty feedback on the implementation feasibility of both approaches.

2. Materials and Methods

All materials were reviewed for content accuracy and appropriate difficulty level by a group of senior faculty members not involved in the study.

2.1. Study design and participants

This was a prospective, crossover, interventional study conducted over five months in the Department of Pharmacology at North DMC Medical College. Sixty Phase-II MBBS students were randomly allocated into two groups of 30 each using a chit-pull system. Ethical approval was obtained from the Institutional Ethics Committee, and written informed consent was secured from all participants.

2.2. Intervention

The Jigsaw method was implemented following the structured approach described by Aronson[7] and adapted for medical education by various researchers.[8,9,26] For each topic, students in the Jigsaw group were divided into six "home groups" of five students each. The topic was divided into five subtopics, each assigned to one member of each home group. For the Calcium Homeostasis topic, subtopics were:(1) Physiology of calcium homeostasis, (2) Calcitonin and its clinical applications, (3) Bisphosphonates, (4) Other drugs affecting calcium metabolism (teriparatide, strontium ranelate, denosumab), and (5) Clinical pharmacology of calcium and vitamin D. For the Thyroid topic, subtopics were: (1) Thyroid hormone synthesis and regulation, (2) Levothyroxine and other thyroid supplements, (3) Thioamides (methimazole, propylthiouracil), (4) Other anti-thyroid drugs (iodine, radioactive iodine), and (5) Clinical management of thyroid disorders.

The Jigsaw session proceeded in three phases. In Phase 1 (20 minutes), students convened in their expert groups—all students assigned to the same subtopic from different home groups met together. Each expert group received focused reading materials, including textbook excerpts, review articles, and clinical vignettes relevant to their subtopic. Students were instructed to discuss the material, clarify concepts among themselves, and prepare to teach their home group. A faculty facilitator circulated among expert groups to answer questions and ensure accurate understanding, but did not provide direct instruction.

In Phase 2 (25 minutes), students returned to their original home groups. Each expert, in turn, taught their subtopic to their home group members. Students were encouraged to ask questions, seek clarifications, and discuss clinical applications. The faculty facilitator observed the process but did not intervene unless misconceptions needed correction.

In Phase 3 (15 minutes), a whole-class discussion was conducted to synthesize the complete topic, address any remaining questions, and highlight key clinical correlations. Students were encouraged to share insights from their expert groups and discuss how the different subtopics integrated into a comprehensive understanding of the topic.

The Traditional Small Group Teaching sessions were designed to reflect standard practice in Indian medical colleges, following guidelines for effective SGT implementation.[6,14,17] For each topic, students in the SGT group were divided into five groups of six. A trained faculty member facilitated each group.

The SGT session proceeded as follows: The facilitator began with a brief introduction (5 minutes) that stated the learning objectives and provided a clinical context for the topic. Students were then given a clinical case scenario related to the topic and asked to discuss it in their small groups (20 minutes). The facilitator guided the discussion by posing probing questions, encouraging participation from all students, and clarifying concepts as needed. Following the small group discussion, each group presented its findings and conclusions to the whole class (15 minutes), with the facilitator providing feedback and elaborating on key points. The session concluded with a facilitator-led summary and synthesis (10 minutes), highlighting the most important concepts and their clinical applications. Throughout the session, facilitators were instructed to ensure balanced participation, address student questions, and maintain focus on the learning objectives. However, unlike the Jigsaw method, students in the SGT group were not assigned specific individual responsibilities for teaching their peers.

To minimize bias and ensure that all students were exposed to both teaching methods, a crossover design was employed. In Session 1 (Week 1, Calcium Homeostasis topic), Group A received SGT while Group B received Jigsaw instruction. In Session 2 (Week 3, Thyroid/Anti-Thyroid Drugs topic), the groups switched methods: Group A received Jigsaw instruction while Group B received SGT. A three-week washout period between sessions was considered sufficient to minimize carryover effects, as the topics were distinct and the assessments were topic specific.

2.3. Assessment tools

Three types of assessments were administered for each topic. Administered immediately before each teaching session, the pre-test consisted of 15 multiple-choice questions (MCQs) designed to assess baseline knowledge of the topic. Questions were based on the learning objectives and were reviewed by faculty for content validity. Each correct answer earned one point, with no negative marking. The maximum possible score was 15. Administered immediately after each teaching session, post-test 2 assessment consisted of 15 MCQs parallel in difficulty and content coverage to the pre-test, but with different questions to minimize recall bias. Questions assessed both factual recall and conceptual understanding. The maximum possible score was 15. Post-test 3 was administered three weeks after each teaching session. This assessment consisted of 15 MCQs similar in format and difficulty to the previous tests, designed to assess long-term retention of the material. Students were not informed in advance about this test to prevent revision.

All assessments were developed by the research team and validated by a panel of senior pharmacology faculty members for content accuracy, clarity, and appropriate difficulty level. A pilot test with 10 students from a non-participating batch was conducted to assess internal consistency, yielding a Cronbach's alpha of 0.81, indicating acceptable reliability.

2.4. Feedback questionnaires

1. **Student feedback:** At the end of the study, after both crossover sessions were completed, students completed a feedback questionnaire assessing their perceptions of both teaching methods. The questionnaire used a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) to evaluate: (1)

engagement in learning, (2) understanding of concepts, (3) enjoyment of the session, (4) collaboration with peers, (5) development of communication skills, (6) confidence in the material, (7) preference for future use, and (8) perceived effectiveness for retention. Open-ended questions allowed students to provide qualitative comments about the strengths and weaknesses of each method.

2. **Faculty feedback:** The three faculty facilitators who conducted the sessions completed a feedback questionnaire, a 5-point Likert scale for assessing their perceptions of: (1) student engagement, (2) ease of implementation, (3) preparation time required, (4) effectiveness for achieving learning objectives, and (5) willingness to use the method in future teaching. Open-ended questions explored perceived challenges and suggested improvements.

2.5. Statistical analysis

Data were entered into Microsoft Excel and analysed using SPSS version 25. Descriptive statistics (mean, standard deviation, frequency, percentage) were calculated for all variables. Normality of data distribution was assessed using the Shapiro-Wilk test.

To compare pre-test, post-test, and retention scores between groups, independent t-tests were used. Within-group comparisons of pre-test versus post-test and post-test versus retention scores were performed using paired t-tests. Learning gain was calculated as the difference between post-test and pre-test scores. Knowledge decay was calculated as the difference between retention and immediate post-test scores.

Repeated-measures ANOVA was conducted to analyse the effects of time (pre-test, post-test, retention) and method (Jigsaw vs. SGT), and their interaction, on test scores, with a Bonferroni correction for multiple comparisons.

For the feedback questionnaire data, Likert-scale responses were summarized as the mean ± SD, and the percentage of students who agreed or strongly agreed with each statement was calculated. Open-ended responses were analysed thematically by two independent researchers, with disagreements resolved through discussion.

Statistical significance was set at $p < 0.05$ for all tests.

3. Results

All 60 enrolled students completed the study, with no dropouts or exclusions. The mean age of participants was 20.4 ± 1.2 years, and the gender distribution was 35 males (58.3%) and 25 females (41.7%). There were no significant differences in age or gender distribution between Group A and Group B at baseline ($p > 0.05$). Attendance at all sessions was 100%, as sessions were conducted during regular scheduled teaching hours.

Pre-test scores were comparable between groups for both topics, confirming successful randomization and absence of prior knowledge differences. For the Calcium Homeostasis topic, mean pre-test scores were 9.2 ± 1.8 in the SGT group and 9.4 ± 1.7 in the Jigsaw group ($p > 0.05$). For the Thyroid topic, mean pre-test scores were 9.5 ± 1.6 in the SGT group and 9.3 ± 1.9 in the Jigsaw group ($p > 0.05$).

Post-test scores revealed significant differences in performance across teaching methods for both topics. For the Calcium Homeostasis topic, the Jigsaw group achieved significantly higher immediate post-test scores (13.8 ± 1.3) compared to the SGT group (12.4 ± 1.6), with a mean difference of 1.4 points (95% CI: 0.7-2.1, $p < 0.001$). Similarly, for the Thyroid topic, the Jigsaw group demonstrated superior performance (14.0 ± 1.1) compared to the SGT group (12.7 ± 1.5), with a mean difference of 1.3 points (95% CI: 0.6-2.0, $p < 0.001$).

Table 1: Post-test and retention scores (Out of 15)

Topic	Group	Post-test Mean ± SD	Retention Mean ± SD
Calcium	SGT	12.4 ± 1.6	11.9 ± 1.7
Calcium	Jigsaw	13.8 ± 1.3	13.4 ± 1.3
Thyroid	SGT	12.7 ± 1.5	12.0 ± 1.6
Thyroid	Jigsaw	14.0 ± 1.1	13.5 ± 1.2

3.1. Learning gains

Learning gains, calculated as the difference between post-test and pre-test scores, were significantly greater for the Jigsaw method across both topics. For the Calcium Homeostasis topic, the mean learning gain was +3.4 marks in the Jigsaw group compared to +2.2 marks in the SGT group ($p < 0.001$). For the Thyroid topic, the mean learning gain was +3.3 marks in the Jigsaw group compared to +2.2 marks in the SGT group ($p < 0.001$). These findings indicate that the Jigsaw method was more effective in facilitating immediate knowledge acquisition.

3.2. Retention analysis

Retention scores at three weeks post-intervention remained significantly higher in the Jigsaw group for both topics. For Calcium Homeostasis, retention scores were 13.4 ± 1.3 in the Jigsaw group versus 11.9 ± 1.7 in the SGT group ($p < 0.001$). For the Thyroid topic, retention scores were 13.5 ± 1.2 in the Jigsaw group versus 12.0 ± 1.6 in the SGT group ($p < 0.001$).

Paired t-tests comparing immediate post-test and retention scores revealed significant knowledge decay in both groups, but the decline was smaller in the Jigsaw group. For the SGT group, the mean decline was -0.5 for Calcium ($p < 0.022$) and -0.7 for Thyroid ($p < 0.009$). For the Jigsaw group, the mean decline was -0.4 for both topics ($p < 0.039$ for Calcium, $p < 0.026$ for Thyroid). These results suggest that the Jigsaw method not only produced better immediate learning but also facilitated superior retention over time.

Table 2: Paired t-test – Post-test vs retention

Group	Topic	Mean Difference	p-value
SGT	Calcium	-0.5	0.022
Jigsaw	Calcium	-0.4	0.039
SGT	Thyroid	-0.7	0.009
Jigsaw	Thyroid	-0.4	0.026

Repeated Measures ANOVA confirmed significant main effects of time ($F = 156.8$, $p < 0.001$) and teaching method ($F = 28.4$, $p < 0.001$) on test scores, as well as a significant time × method interaction ($F = 12.6$, $p < 0.001$). The interaction effect shows that the pattern of change over time (pre-test to post-test to retention) differed significantly between the Jigsaw and SGT methods, with the Jigsaw group proving both greater initial gains and better retention.

3.3. Student feedback

It was observed that more than 70% of the students would appreciate more sessions using the Jigsaw method of teaching in the future. Students said that the Jigsaw method of teaching led to better communication and collaboration with their peers. There was more active involvement of students and better understanding of concepts when a topic was taught using the Jigsaw method of teaching in comparison to the Small Group Discussion method of teaching. Hence, over 70% of students preferred the Jigsaw method, citing better peer communication, collaboration, and active involvement.

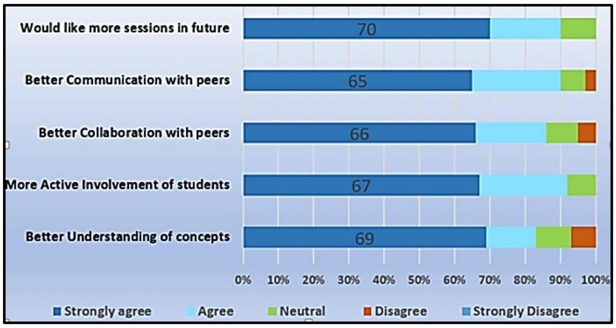

Figure 1: Student feedback: Jigsaw vs small group teaching method

The students thought that the jigsaw method was highly effective because teaching their peers forced them to understand the material rather than just memorizing it. They appreciated that the format required everyone to take part, preventing anyone from passively observing, and they found that expert group discussions helped clarify difficult concepts before they had to teach them. Many students also noted that they retained the information better—particularly recalling topics like the thyroid—because they had taught it to others, and they found the approach more interactive and enjoyable than regular small-group work. On the other hand, students expressed frustration when some experts came unprepared, as this directly hindered their group's learning. They also felt that the method took more time than traditional teaching, which limited how much content they could cover, and they observed that certain subtopics were inherently more difficult, leading to uneven workloads among experts.

Regarding SGT, students appreciated the facilitator's guidance but noted few limitations. The students thought that while the teacher explained concepts clearly, the format left them feeling less actively involved in their own learning. They observed that discussions were often dominated by a few outspoken individuals, while others remained silent and disengaged throughout the session. Additionally, students felt that although they could understand the material during class, the information was quickly forgotten afterward, suggesting that passive listening without active participation did not support long-term retention

3.4. Faculty feedback

All three faculty facilitators completed the feedback questionnaire.

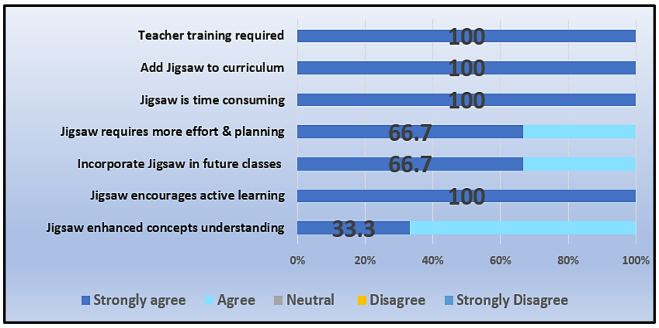

Figure 2; Faculty feedback: Jigsaw vs small group discussion

Table 3: Faculty perceptions of teaching methods (n=3)

Statement	Jigsaw Method (Mean ± SD)	SGT Method (Mean ± SD)
Student engagement was high	4.7 ± 0.6	3.3 ± 0.6
Easy to implement	3.0 ± 0.0	4.3 ± 0.6
Preparation time was reasonable	2.7 ± 0.6	4.0 ± 0.0
Effective for achieving learning objectives	4.3 ± 0.6	3.7 ± 0.6
Would use this method in future teaching	4.0 ± 0.0	4.3 ± 0.6

Qualitative faculty comments highlighted both strengths and challenges. The learning faculty observed that the jigsaw method led to remarkable student engagement, with even typically quiet students participating actively in their expert groups. They believed that the peer-teaching component reinforced learning in ways that facilitator-led discussions could not, and they observed students employing higher-order thinking as they prepared to teach complex concepts to their classmates. However, faculty found the preparation process time-consuming, as developing appropriate materials for each expert group required careful planning. They also noted the need for close monitoring to ensure all expert groups developed an accurate understanding, and they observed that some students struggled with the responsibility of teaching their peers. In contrast, faculty thought the Small Group teaching (SGT) method was easier to implement with existing resources and required less preparation time. They appreciated that the facilitator could ensure all key points were covered, but they observed that student participation was variable and that students seemed more passive overall compared to the jigsaw sessions.

4. Discussion

This prospective crossover study provides robust evidence that the Jigsaw method is more effective than Traditional Small Group Teaching in enhancing both immediate learning and long-term retention of pharmacology concepts among Phase-II medical students. The findings have significant implications for pharmacology education and align with the growing emphasis on active, student-centred learning strategies in competency-based medical curricula.[1,2,5]

The superior immediate learning outcomes observed with the Jigsaw method can be understood through the lens of social constructivist theory.[10,12] In the Jigsaw classroom, students are not passive recipients of information but active constructors of knowledge who must master their assigned subtopic sufficiently to teach it to peers. This "learning by teaching" paradigm engages deeper cognitive processing than simply listening to a facilitator-led discussion.[11,31] As students prepare to teach, they organize information, identify key concepts, anticipate questions, and develop explanations—all activities that promote meaningful learning and knowledge integration.[32]

The finding that Jigsaw produced learning gains approximately 50% greater than SGT (+3.3 marks to +3.4 marks vs. +2.2 marks out of 15 marks) is consistent with previous research comparing cooperative learning methods to traditional instruction. A meta-analysis by Johnson et al.[13] found that cooperative learning consistently outperforms competitive and individualistic learning across multiple outcomes, with effect sizes ranging from moderate to large. In medical education contexts, studies have reported similar advantages for Jigsaw over lectures[27,33] and over other active learning methods.[30]

The superior retention observed with the Jigsaw method is particularly noteworthy, given the importance of long-term knowledge retention for clinical practice.20 [20]. The smaller knowledge decay in the Jigsaw group (-0.4 points) compared to SGT (-0.5 to -0.7) suggests that the deeper cognitive processing involved in peer teaching creates more durable memory traces.[31] This finding aligns with research on the "testing effect" and "generation effect" in cognitive psychology, which demonstrate that actively retrieving and generating information strengthens memory more than passive review.[34] When students teach their peers, they engage in repeated retrieval and elaboration of the material, which enhances consolidation and subsequent recall.[35]

The crossover design strengthens confidence in these findings by controlling for student characteristics and topic difficulty. The consistency of results across two different pharmacology topics (Calcium Homeostasis and Thyroid/Anti-Thyroid Drugs) suggests that the Jigsaw method's effectiveness generalizes across content areas, increasing the external validity of the findings. Our findings align with and extend previous research on the Jigsaw method in health professions education. Persky and Pollack[26] demonstrated that a hybrid Jigsaw approach effectively taught renal clearance concepts to pharmacy students, with students achieving learning outcomes comparable to traditional instruction. Wilson et al.[28] found that Jigsaw learning for medication therapy management provided cooperative learning and communication benefits beyond content mastery. Phillips and Fusco[29] reported that the Jigsaw method successfully engaged students in learning clinical controversy, fostering a deeper understanding of complex topics.

More recent studies have reinforced these findings. Chng et al.[27] evaluated Jigsaw collaborative learning for teaching pharmacokinetics to pharmacy students and observed learning gains of 14.3% through peer teaching alone, with students appreciating the active discussions and collaboration. Moin et al.[9] assessed the impact of the Jigsaw technique in undergraduate medical education and reported merits including enhanced engagement, improved peer teaching skills, and positive student perceptions, while also noting challenges related to time consumption and student preparedness.

A comparative study by Yadav et al.[30] found that Jigsaw Learning slightly outperformed Case-Based Learning in post-test performance among postgraduate medical students, with 95.5% of students strongly agreeing that Jigsaw Learning was enjoyable. However, only 63.6% felt it was beneficial for memory retention—a finding that contrasts with our observation of superior retention with Jigsaw. This discrepancy may reflect differences in study populations (postgraduate vs. undergraduate), assessment timing, or outcome measures.

Our finding that 73.3% of students preferred Jigsaw for future pharmacology topics is consistent with previous research reporting high student satisfaction with cooperative learning methods.[36] The particularly high ratings for collaboration (90%) and communication skills development (85%) align with the Jigsaw method's intended outcomes and support its value for developing the non-technical competencies emphasized in modern medical curricula.[2,5]

The findings support Vygotsky's social constructivist framework[10] and its application to medical education.[11,12] In the Jigsaw classroom, the expert groups function as zones of proximal development where students collaboratively construct understanding with peers who may have slightly different perspectives or strengths. The home groups then provide opportunities for students to consolidate their learning by teaching others, a process that requires them to articulate, clarify, and defend their understanding.

The results also align with the principles of cooperative learning articulated by Johnson and Johnson;[13,32] positive interdependence (students need each other to learn all subtopics), individual accountability (each student must master and teach their subtopic), promotive interaction (students support each other's learning), appropriate use of social skills (communication, leadership, conflict resolution), and group processing (reflecting on how well the group functioned). The Jigsaw method systematically incorporates all five elements, whereas traditional SGT may not ensure positive interdependence or individual accountability to the same degree.

5. Practical Implications for Pharmacology Education

The findings have several practical implications for pharmacology educators and curriculum planners in the context of CBME implementation:

The Jigsaw method can be effectively integrated into existing pharmacology curricula for conceptually complex topics that can be divided into interrelated subtopics. Suitable topics might include autonomic nervous system drugs, cardiovascular drugs, chemotherapy, and drug interactions—all areas where understanding the relationships between subtopics is critical.[37] Implementing Jigsaw effectively requires faculty training in facilitating cooperative learning, developing appropriate expert group materials, and managing the logistics of multiple small groups working simultaneously.[38] Medical colleges should invest in faculty development programs that equip teachers with these skills, as mandated by NMC guidelines for CBME implementation.[2] While Jigsaw requires more preparation time than SGT (as noted by faculty in this study), it does not necessarily require additional physical resources or faculty numbers. The same faculty-to-student ratio can be maintained in both techniques. This makes Jigsaw feasible even in resource-limited settings where faculty availability is constrained.[6,18] The finding that Jigsaw promotes superior retention suggests that assessment strategies should align with this deeper learning. Rather than relying solely on factual recall questions, assessments should evaluate students' ability to integrate knowledge across subtopics, apply concepts to clinical scenarios, and explain relationships—all competencies that Jigsaw learning develops.[39] The success of Jigsaw depends partly on student preparedness and motivation. Faculty should orient students to the method's rationale and expectations, emphasize the importance of expert group preparation, and provide guidance on effective peer teaching strategies.[9]

6. Comparison with Other Active Learning Methods

The effectiveness of the Jigsaw method should be considered within the broader landscape of active learning strategies in medical education. Research has demonstrated the value of various approaches, including spaced learning,[22] case-based learning[23,40] team-based learning,[24] and inquiry-based learning.[41]

Spaced learning, which distributes study sessions over time, has shown significant advantages over traditional massed learning for knowledge retention in pharmacology.[22] The spaced learning group in Deori et al.'s study achieved post-test scores of 82.1% compared to 72.3% for traditional learning, with similarly superior retention and satisfaction.[22] This approach could potentially complement Jigsaw by incorporating spaced review of material learned through peer teaching.

Case-based learning has been extensively studied in pharmacology education.[23] Alhassan et al.[40] found that while short-term retention was slightly higher with lectures, long-term retention favoured CBL, with a significant decline in knowledge-based questions for lectures while CBL maintained retention over four weeks. This pattern parallels our finding of better retention with Jigsaw and suggests that active learning methods promote more durable learning than passive approaches.

Team-based learning, which combines individual preparation, team application, and immediate feedback, has demonstrated effectiveness in foundational pharmacokinetics courses[24] and has been widely adopted in medical curricula.[42] While TBL and Jigsaw share elements of cooperative learning and individual accountability, Jigsaw uniquely emphasizes peer teaching as the mechanism for knowledge dissemination, which may explain its effectiveness for developing communication skills and deepening understanding through explanation.

7. Limitations

This study has several limitations that should be acknowledged. The study was conducted at a single medical college in Delhi, which may limit generalizability to other settings with different student demographics, faculty expertise, or institutional resources. Multi-centre studies are needed to confirm the findings across diverse contexts. While the sample size was adequate to detect statistically significant differences, a larger sample would provide more precise effect estimates and allow subgroup analyses (e.g., by gender, prior academic performance). Retention was assessed at three weeks, which, while longer than many studies, does not address long-term retention over months or years. Future research should evaluate whether the Jigsaw method's retention advantage persists over longer intervals relevant to clinical practice.

Knowledge was assessed using MCQs, which primarily measure factual recall and basic comprehension. Future studies should include assessments of higher-order cognitive skills, such as clinical reasoning, problem-solving, and application to novel scenarios, using formats like objective structured clinical examinations (OSCEs), key feature problems, or clinical reasoning tasks.[39] Despite the crossover design and washout period, the possibility of carryover effects cannot be completely excluded. Students' experience with one method may have influenced their approach to the subsequent method, although the distinct topics minimize this concern. Different facilitators conducted the SGT sessions, and while efforts were made to standardize facilitation, individual facilitator characteristics may have influenced outcomes. The crossover design helps mitigate this concern, as each facilitator taught both methods across the two topics. The study did not assess students' prior experience with cooperative learning or their individual learning preferences, which might moderate the effectiveness of different teaching methods. Future research should explore whether student characteristics predict differential responses to Jigsaw versus SGT.

While the research team monitored sessions to ensure adherence to protocols, variations in implementation fidelity may have occurred, particularly in student-led expert groups where facilitator oversight was limited.

8. Future Directions

Building on these findings, several directions for future research emerge. Studies should evaluate whether the Jigsaw method's benefits for knowledge retention translate into improved clinical performance, including OSCE scores, clinical reasoning assessments, and, patient care outcomes. Research should explore the cognitive and social mechanisms underlying Jigsaw's effectiveness. Process-oriented studies using think-aloud protocols, video analysis of group interactions, or pre/post-measures of metacognitive awareness could illuminate how Jigsaw learning produces its effects.[43] Given the increasing role of technology in medical education, research should examine whether Jigsaw can be effectively implemented in hybrid or fully online formats.[27,44] Modified Jigsaw approaches incorporating digital tools, such as educational videos or online discussion forums, warrant investigation.[45] Head-to-head comparisons of Jigsaw with other active learning methods (TBL, PBL, CBL, flipped classroom) would help educators select the most appropriate method for specific learning objectives, content areas, and student populations.[30,41] Research should identify barriers and facilitators to Jigsaw implementation in diverse medical education contexts, develop implementation strategies, and evaluate scalability and sustainability.[38]

Studies should examine whether Jigsaw differentially benefits students from diverse backgrounds, including those with different learning styles, prior academic preparation, or cultural attitudes toward collaboration. Research should investigate effective approaches to training faculty in Jigsaw facilitation, including the competencies required and the most efficient training methods.

9. Conclusion

This prospective crossover study demonstrates that the Jigsaw method is a viable and superior alternative to Traditional Small Group Teaching in Pharmacology education for Phase-II medical students. The Jigsaw method produced superior immediate learning outcomes, with learning gains approximately 50% greater than SGT, and better long-term retention, with less knowledge decay over three weeks. Student feedback strongly favoured Jigsaw, particularly for collaboration, communication skills development, and engagement, with 73.3% preferring Jigsaw for future pharmacology topics. Faculty acknowledged the method's effectiveness despite greater preparation time requirements.

The findings align with social constructivist learning theory and the principles of effective cooperative learning. The Jigsaw method's structured approach ensures positive interdependence and individual accountability, promoting deeper cognitive processing through peer teaching and collaborative knowledge construction. In the context of India's Competency-Based Medical Education curriculum, which emphasizes active learning and the development of collaborative competencies, the Jigsaw method offers a valuable pedagogical strategy.

We recommend that pharmacology educators consider integrating the Jigsaw method into their teaching repertoire, particularly for conceptually complex topics where understanding relationships between subtopics is critical. Faculty development programs should include training in Jigsaw facilitation, and curriculum planners should allocate time and resources to support its implementation. Future research should explore the method's long-term impact on clinical performance, its effectiveness in online formats, and optimal strategies for scaling and sustaining its use across medical education contexts.

By fostering active, collaborative, and student-centred learning, the Jigsaw method can help develop future clinicians who not only possess strong foundational knowledge but also the communication, teamwork, and peer-teaching skills essential for contemporary medical practice.

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11. Conflict of Interest Statement

The authors declare no conflicts of interest.

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