“Effectiveness of two different innovative teaching learning methods: A comparative analysis among phase 1 MBBS students”

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Title: "Effectiveness of two different innovative teaching learning methods: A comparative analysis among phase 1 MBBS students"

Abstract:

Background: Active learning strategies are increasingly incorporated into competency-based medical education to promote student engagement, collaborative learning, and higher-order cognitive skills. Although both cooperative learning methods have demonstrated educational benefits, evidence comparing different active learning strategies among undergraduate medical students remains limited. This study compared the effectiveness of the jigsaw technique and student-generated flip flashcard learning in improving learning outcomes among Phase I MBBS students. **Methods:** A quasi-experimental comparative study was conducted among phase 1 MBBS students at a teaching medical college in India. Following Institutional Ethics Committee approval, 75 consenting students were enrolled and allocated into two comparable groups using alternate allocation based on previous formative assessment scores. One group (n = 38; mean previous score: 50.6 ± 11.55) were exposed through the jigsaw technique, while other group (n = 37; mean previous score: 53.0 ± 9.55) participated in student-generated flip flashcard learning. The competency selected was BI 7.2 (Protein Biosynthesis) from the National Medical Commission competency-based curriculum. Learning outcomes were assessed immediately after the intervention using a validated questionnaire comprising multiple-choice questions, fill-in-the-blanks, and short-answer questions. Student perceptions were also collected using a structured feedback questionnaire. To ensure educational equity, both groups received the alternate intervention during the subsequent week; however, only the first intervention data were included in the analysis. Group comparisons were performed using the Brunner–Munzel test following assessment of data normality. **Results:** The two groups were comparable (p value 0.33) in baseline academic performance. Students exposed to the jigsaw technique achieved significantly higher post-test scores than those participating in student-generated flip flashcard learning. The mean post-test score was 15.0 in the jigsaw group compared with 9.86 in the flip flashcard group, and the difference was statistically highly significant ($p < 0.001$). Students also reported greater engagement, peer interaction, and conceptual understanding with the jigsaw technique. **Conclusions:** The jigsaw technique was more effective than student-generated flip flashcard learning in improving immediate learning outcome. Incorporating structured cooperative learning into competency-based undergraduate medical education may enhance both academic performance and collaborative learning skills. Further multicentric studies and evaluating long-term knowledge retention and application are warranted.

Trial registration: NA

Keywords: Jigsaw; Cooperative learning; Active learning; Biochemistry; Competency-based medical education; Medical students; innovative teaching learning method; flip flash card

Background

The medical education has progressively shifted from traditional teacher-centred approach towards learner-centred approaches that actively engage students in learning. Active learning strategies encourage students to participate in educational activities rather than passively receiving information. This improves critical thinking, problem-solving, communication, collaboration, and long-term retention of knowledge. Interactive learning methods have consistently demonstrated superior learning outcomes compared with conventional didactic teaching in undergraduate medical education(1–5). Competency-Based Medical Education (CBME), introduced in medical undergraduate (MBBS) in India, emphasizes not only acquisition of knowledge but also development of communication skills, teamwork, professionalism, self-directed learning, and lifelong learning competencies expected of the Indian Medical Graduate(6). Consequently, medical educators are increasingly adopting innovative teaching-learning methods that foster active participation and collaborative learning to achieve these competencies.

Among the various learner-centred strategies, the Aronson jigsaw technique is a structured cooperative learning method in which students first become experts in one component of a topic through discussion in expert groups and subsequently teach the acquired knowledge to their peers in home groups. This strategy promotes positive interdependence, individual accountability, peer teaching, communication skills, and collaborative learning(7). Cooperative learning has been shown to improve both academic achievement and student's perception of social and academic support compared with conventional learning approaches(8,9)

Another active learning approach increasingly used by medical students is the flashcard-based learning strategy. Flashcards facilitate active recall and repeated retrieval of information, which are known to strengthen memory consolidation and improve long-term retention. Student-generated flip flashcards further encourage learners to identify key concepts, organize information, and actively construct learning resources, thereby promoting self-directed learning. Despite their widespread use by medical students, evidence evaluating flashcard creation as a structured classroom teaching-learning strategy remains limited, particularly when compared with other collaborative learning methods.(10–12)

Biochemistry is one of the fundamental subjects taught during the early phase of the medical curriculum. However, it is often perceived as challenging because of its extensive factual content and the need to integrate fundamental biochemical concepts with their clinical applications. Active learning approaches may facilitate better understanding of these concepts by promoting deeper cognitive processing and peer interaction. Although several studies have independently demonstrated the benefits of jigsaw learning and other innovative teaching-learning methods(1,3,13–17). Comparative evidence evaluating different active learning strategies within the same educational setting remains scarce. Furthermore, there is limited evidence comparing the effectiveness of jigsaw learning and student-generated flip flashcard learning among Phase I MBBS students studying Biochemistry under the CBME curriculum.

Therefore, the present study aimed to compare the effectiveness of two innovative teaching-learning methods—jigsaw and student-generated flip flashcard learning—in improving learning outcomes among Phase I MBBS students in Biochemistry.

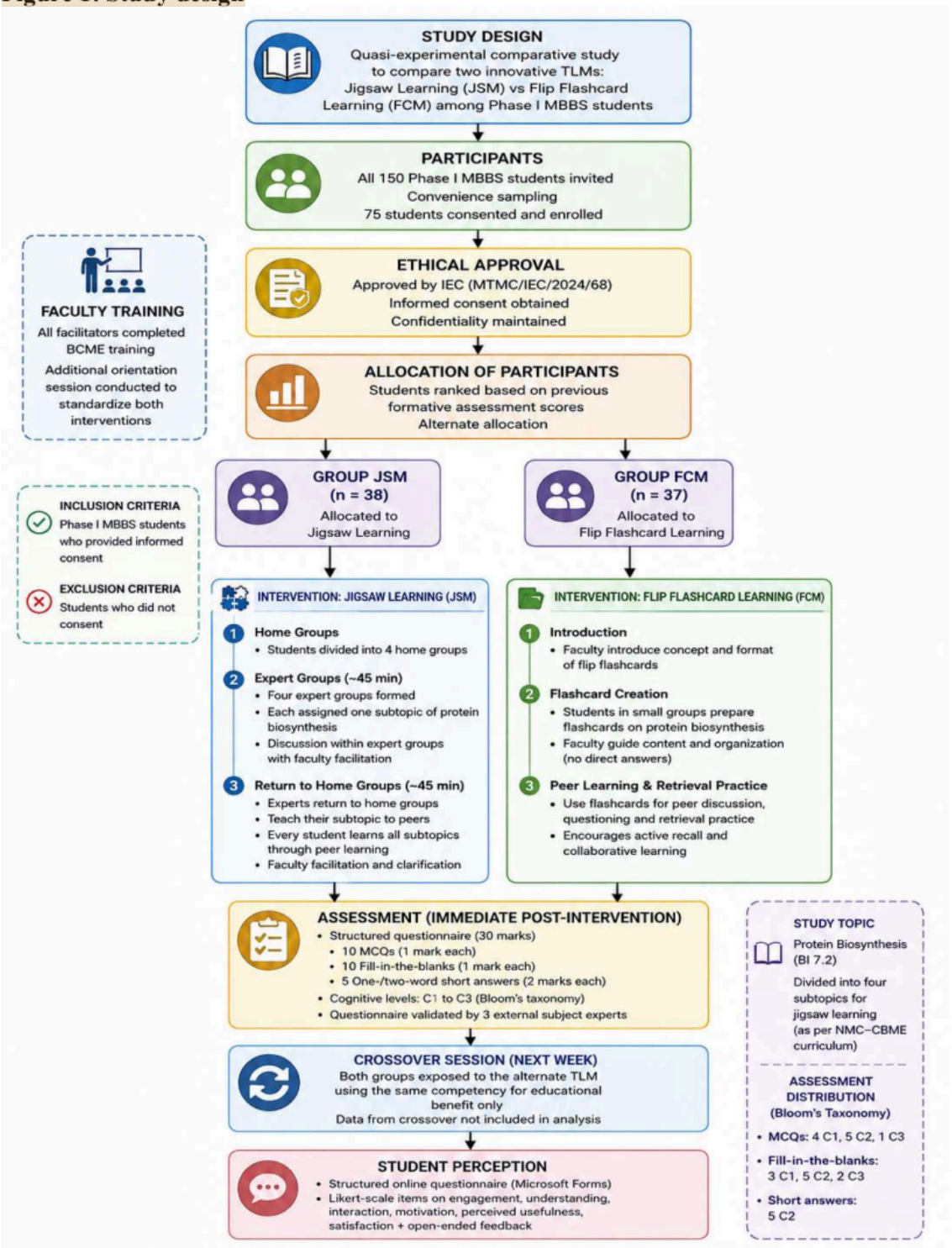
Methods:

Study design:

A quasi-experimental comparative study was conducted to compare the effectiveness of two innovative teaching-learning methods (TLMs), namely jigsaw learning (JSM) and student-generated flip flashcard learning (FCM), among Phase I MBBS students. Students were allocated into two comparable groups using stratified alternate allocation based on their previous formative assessment scores. They were exposed to corresponding teaching-learning

method and immediate post-intervention assessment was conducted as post-test. Student's perceptions regarding the teaching-learning methods were also collected at the end of the session. **(Figure 1)**

Figure 1: Study design



Study setting and participants:

The study was conducted in the department of Biochemistry at a medical college in India during the Phase I MBBS course. All 150 phase 1 MBBS students of the academic session were invited to participate. As no previous study comparing these two interventions was available for effect size estimation, convenience sampling was adopted. Students who provided informed consent were included in the study, while those who declined participation were excluded. A total of 75 students consented and were enrolled.

Ethical approval

The study was approved by the Institutional Ethics Committee (IEC) (Approval No.: MTMC/IEC/2024/68). Participation was voluntary, and students were informed that their decision to participate or withdraw would not influence their academic assessment. Informed consent was obtained from all participants. Confidentiality of participant's identity and assessment scores was maintained throughout the study, and the scores were used solely for research purposes.

Faculty training

All faculty members involved in the study as facilitator had previously undergone Basic Course in Medical Education Training (BCME). Before commencement of the study, an additional orientation session for facilitator was conducted to standardize the implementation of both jigsaw learning and flip flashcard teaching-learning methods, ensuring uniform delivery of the interventions.

Allocation of participants

To ensure comparability between groups, students were ranked according to their scores obtained in the previous formative assessment in Biochemistry. The ranked list was arranged in order, and stratified alternate allocation was done. The highest-scoring student was allocated to Group JSM, the second highest to Group FCM, the third to Group JSM, and so forth until all participants were allocated. This resulted in 38 students in Group JSM and 37 students in Group FCM. Baseline academic performance based on previous formative assessment of the two groups was comparable.

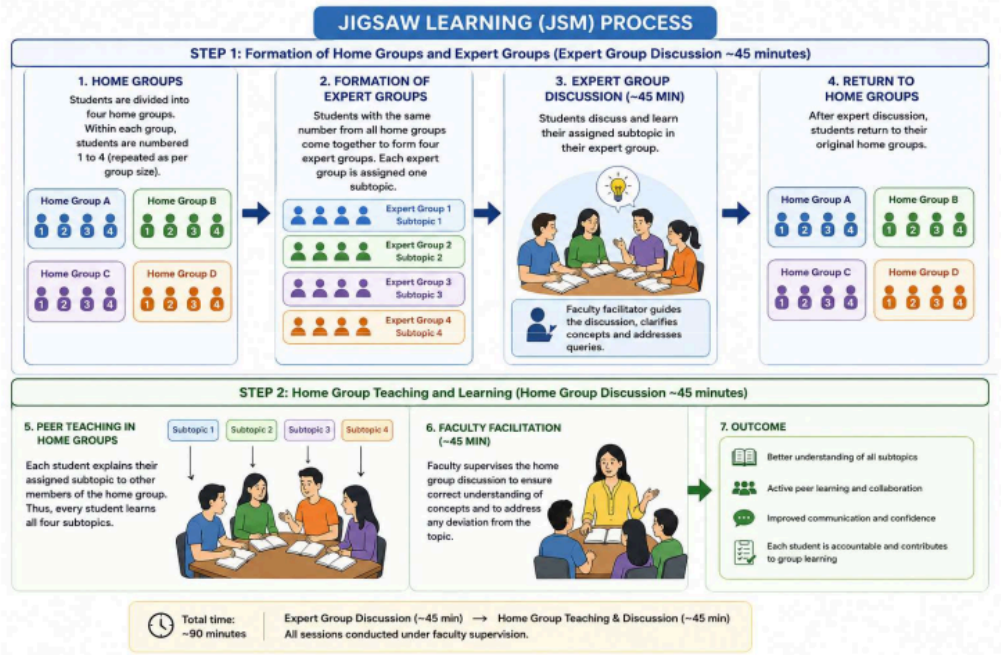
Educational intervention

Study topic - The competency selected for the study was BI 7.2 (Protein Biosynthesis) from the National Medical Commission (NMC) – Competency Based Medical Education curriculum (CBME) for undergraduate medical students. (6)The topic was divided into four subtopics to facilitate jigsaw learning.

Jigsaw learning - Students assigned to the jigsaw learning Group (JSM) were first divided into four home groups. Within each home group, students were numbered from 1 to 4, and this numbering was repeated depending on the group size. Each number corresponded to one of the four subtopics of protein biosynthesis. Students with the same number from all home groups then came together to form four expert groups, with each expert group working on a specific subtopic. The expert groups discussed and learned their assigned subtopic for approximately 45 minutes under the guidance of a faculty facilitator, who clarified concepts and addressed students' queries.

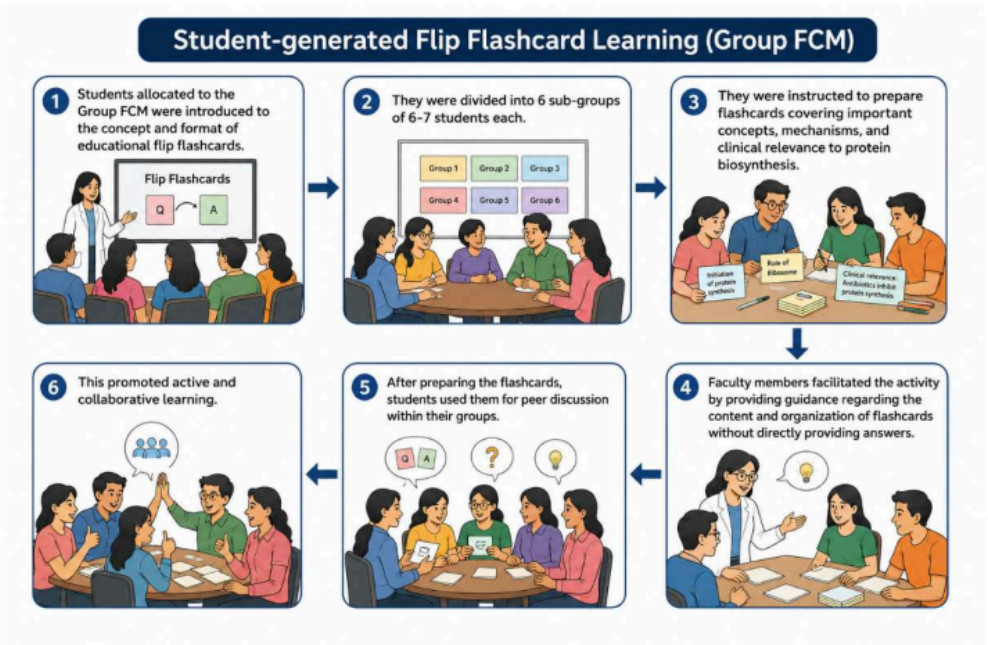
After the expert group discussion, students returned to their original home groups. Each student then explained their assigned subtopic to the other members of the home group, allowing everyone to learn all four subtopics through peer teaching and collaborative discussion. This home group session lasted for approximately 45 minutes and was conducted under faculty supervision to ensure that concepts were understood correctly and any deviation from the topic was addressed. (Figure 2)

Figure 2: Study design for jigsaw learning



Student-generated flip flashcard learning - Students allocated to the Group FCM were introduced to the concept and format of educational flip flashcards. They were divided into 6 sub-groups of 6-7 students each. They were instructed to prepare flashcards covering important concepts, mechanisms, and clinical relevance to protein biosynthesis. Faculty members facilitated the activity by providing guidance regarding the content and organization of flashcards without directly providing answers. After preparing the flashcards, students used them for peer discussion within their groups, promoting active and collaborative learning. (Figure 3)

Figure 3: Study design for Flip-flash card learning



Assessment - Participants completed a post-test immediately after the intervention for assessment. The assessment questionnaire consisted of 30 marks, including: 10 multiple-choice questions (1 mark each), 10 fill-in-the-blank questions (1 mark each), and 5 one- or two-word short-answer questions (2 marks each). This included C1 to C3 cognitive levels as per Bloom's taxonomy **(Table 1).** The questionnaire was developed and validated by three external subject experts (Associate Professor or above) from Departments of Biochemistry at different medical colleges in India. Necessary modifications were incorporated based on expert recommendations before implementation.

Table 1: The distribution of assessment questions according to Bloom's taxonomy

Question type	Number of questions	Bloom's taxonomy level
Multiple-choice questions	4	C1 (Remember)
	5	C2 (Understand)
	1	C3 (Apply)
Fill-in-the-blanks	3	C1 (Remember)
	5	C2 (Understand)
	2	C3 (Apply)
One-/two-word short-answer questions	5	C2 (Understand)

Crossover session - To ensure participant academically balanced to the allocation to a particular teaching-learning method, both groups were exposed to the alternate teaching-learning strategy during the subsequent week using the same competency. The crossover session was conducted solely for educational purposes, and data from the crossover intervention were not included in the comparative analysis.

Student perception

Immediately after the intervention, students' perceptions of the teaching–learning method were collected using a structured online feedback questionnaire administered through Microsoft Forms. The questionnaire comprised items rated on a 5-point Likert scale to assess student engagement, conceptual understanding, interaction, motivation, perceived usefulness, and overall satisfaction. It also included open-ended questions to obtain qualitative feedback on students' learning experiences.

Statistical analysis

Data were entered into Microsoft Excel and analysed using Jamovi version 2.3 (The jamovi Project, Sydney, Australia).(18) Descriptive statistics were expressed as mean ± standard deviation (SD) for continuous variables and frequencies with percentages for categorical variables. Normality of the assessment scores was evaluated using the Shapiro–Wilk test. Baseline comparability between the two groups was assessed using the pre-test scores. As the post-test scores were not normally distributed, comparisons between groups were performed using the Brunner–Munzel test. A two-sided p value <0.05 was considered statistically significant.

Results:

Among the 150 eligible Phase I MBBS students, 75 consented to participate and were included in the study. Based on stratified alternate allocation using previous formative assessment scores, 38 students were allocated to the jigsaw group and 37 to the student-generated flip flashcard group. The two groups were comparable at baseline with respect to their previous formative assessment scores (50.6 ± 11.55 vs. 53.0 ± 9.55, with p value of 0.33).

The distribution of post-test scores was assessed using the Shapiro–Wilk test and was found to be skewed. Therefore, the Brunner–Munzel test was used to compare the post-test scores between the two groups.

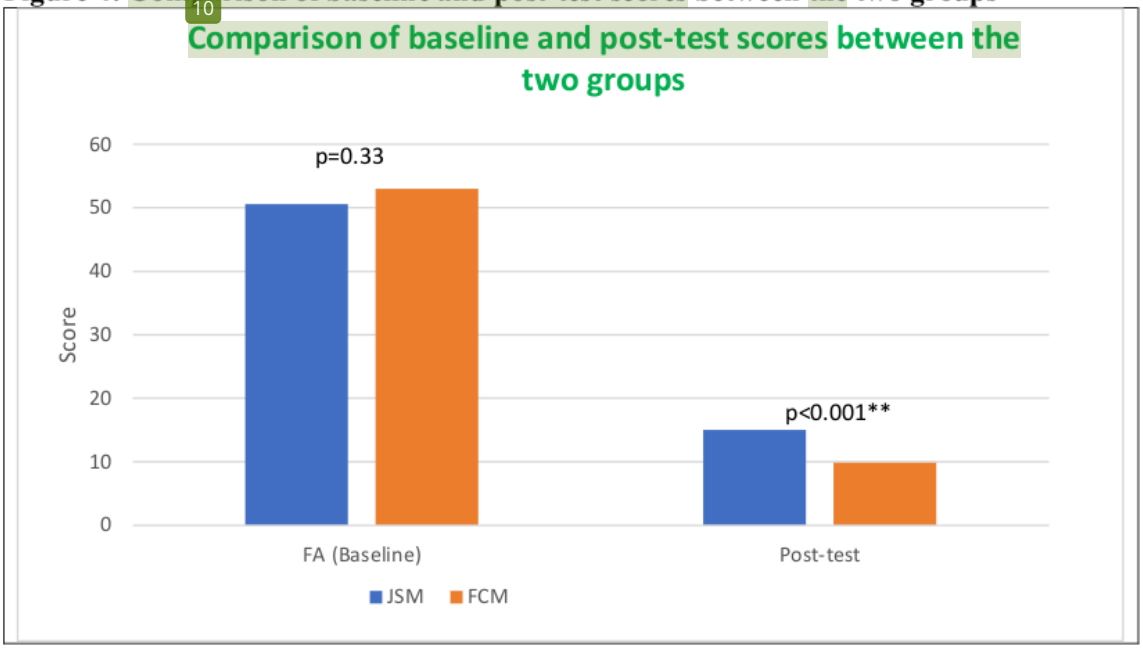
Students who underwent the jigsaw intervention demonstrated significantly better performance than those who participated in the student-generated flip flashcard activity. The mean post-test score was 15.0 in the jigsaw group compared with 9.86 in the flip flashcard group, and the difference was statistically significant ($p < 0.001$). The magnitude of the difference was large (rank-biserial correlation = 0.525). (Table 2, Figure 4)

Table 2: Comparison of baseline and post-test scores between the two groups

Group	n	Formative assessment score (mean ± SD)	Post test scores			
			Brunner–Munzel test (mean score)	Median	Range	IQR
Group JSM	38	50.6 ± 11.55	15.00	15	6-27	7.00
Group FCM	37	53.0 ± 9.55	9.86	8	1-24	5.75
p value		0.33	<0.001**			
Effect size (Rank-biserial r)	--	--	0.525			

** Highly significant

Figure 4: Comparison of baseline and post-test scores between the two groups



** highly significant

Feedback:

As per students' perception, among the TLM, Jigsaw was preferred over flip flash card. Jigsaw learning was viewed positively because it encouraged active participation, peer teaching, collaborative learning, and deeper conceptual understanding. The primary limitation identified was that it is more time-intensive and may involve unequal participation among students.

Flip flash card making was valued as an easy, self-paced, and effective revision strategy, with participants highlighting its usefulness as portable short notes for future study. The few disadvantages reported included the additional effort required for preparation and reduced interaction compared with small group teaching (SGT).

Table 3: Qualitative Analysis Summary

Question	Major themes	Interpretation
Advantages of Jigsaw over regular SGT	Better understanding, peer teaching, interaction, collaboration	Jigsaw enhanced understanding through active peer learning and teamwork.
Disadvantages of Jigsaw over regular SGT	Time-consuming, preparation burden, unequal participation	Main concerns were increased time, preparation, and unequal participation.
Advantages of Flip Flash Card TLM over regular SGT	Easy learning, revision, self-paced learning, convenience	Flip flash cards supported self-learning and effective revision.
Disadvantages of Flip Flash Card TLM over regular SGT	Greater effort, limited interaction, passive learning	Few drawbacks included extra effort and reduced interaction.

Discussion:

This quasi-experimental study compared two learner-centred teaching-learning methods-jigsaw and student-generated flip flashcard making, for teaching protein biosynthesis to Phase I MBBS students. Students who learned through the jigsaw method achieved significantly higher immediate post-test scores than those who used student-generated flip flashcards. Student feedback also showed that jigsaw learning was perceived as more interactive, engaging, and helpful for understanding difficult concepts through peer teaching and collaborative discussion. The study findings suggest that, while both methods offered distinct educational benefits, jigsaw learning is better strategy for teaching conceptually challenging topics in undergraduate medical education.

The superior performance of the jigsaw group can be explained by the principles of social constructivism and cooperative learning. In the jigsaw approach, students first develop expertise in one component of the topic within expert groups before returning to their home groups to teach their peers. This process requires learners to retrieve, organise, elaborate, and explain information, resulting in deeper cognitive processing than passive learning. Furthermore, positive interdependence and individual accountability ensure that every student contributes meaningfully to group learning. Beyond improving knowledge acquisition, jigsaw learning also develops communication skills, teamwork, leadership, and self-confidence, competencies that are emphasised within the National Medical Commission's Competency-Based Medical Education (CBME) curriculum. (6,8,9,19,20)

Although the flip flashcard-making group demonstrated lower post-test scores, students reported positive perceptions of the learning experience, suggesting that learner satisfaction did not necessarily correspond with short-term knowledge gains. This finding is likely explained by the intervention design. Students spent a substantial portion of the classroom session creating their own flashcards, leaving limited opportunity for repeated retrieval practice, the principal mechanism responsible for flashcard effectiveness. Since retrieval practice produces the greatest learning gains when repeated over time and combined with spaced repetition(10–12), the present findings suggest that student-generated flashcards may be less effective than structured peer teaching for improving immediate learning within a single classroom session.

The present findings are consistent with previous studies demonstrating the educational effectiveness of jigsaw learning across medical education. Singaravelu et al. reported significantly higher academic performance among Phase III MBBS students using jigsaw learning compared with conventional small-group teaching(13).Similarly, Prashanti et al. demonstrated superior post-test performance and knowledge retention among dental students following jigsaw-based instruction.(7)Furthermore, Moin et al., in a mixed-methods study, found that both students and faculty perceived jigsaw learning as an engaging strategy that enhanced academic performance, teamwork, learner motivation, communication skills, and active participation.(16) Collectively, these studies reinforce the growing evidence supporting cooperative learning as an effective instructional strategy across health professions education(8,16,21).

In contrast, the present findings regarding flip flashcards should be interpreted in light of evidence demonstrating that flashcards are most effective when used repeatedly for retrieval practice over time rather than being created and used within a single teaching session (10–12). Thus, the comparatively lower immediate post-test scores observed in this study are more likely related to the instructional design than to any inherent limitation of flashcard-based learning.

The qualitative findings of the study complement the quantitative results by providing insight into students' learning experiences. Participants consistently reported that jigsaw learning promoted better conceptual understanding, meaningful peer interaction, collaborative learning, and improved communication skills. Many students appreciated learning from classmates who explained concepts in simple and relatable language, making complex concepts easier to understand. These perceptions reinforce the educational value of peer-assisted learning, where knowledge is actively constructed through discussion and explanation.

Students also identified practical challenges associated with jigsaw learning, including the greater time required for discussion, unequal participation among group members. Similar concerns have been reported previously thus highlighting the importance of effective faculty facilitation, clearly defined learner responsibilities, and adequate time allocation for successful implementation (8,9,16).

Interestingly, students viewed the two teaching-learning methods as serving complementary rather than competing purposes. While jigsaw learning was preferred for conceptual understanding and collaborative learning, flip flashcards were valued primarily as a revision aid that supported self-directed learning. These complementary strengths suggest that the two approaches can be integrated to support different phases of learning.

The present findings have important implications for competency-based medical education. Jigsaw learning appears particularly suitable for introducing conceptually difficult topics that require active discussion, collaboration, and peer teaching, whereas student-generated flip flashcards may be better suited for subsequent revision and reinforcement through self-directed retrieval practice. Integrating these complementary learner-centred approaches within the CBME curriculum may facilitate both deep conceptual understanding and long-term knowledge retention while simultaneously promoting communication, teamwork, and lifelong learning skills expected of future medical graduates.

A major strength of this study is the direct comparison of two learner-centred teaching-learning strategies rather than comparing an innovative method with traditional lectures or small-group teaching. Additional strengths include comparable baseline academic performance between groups, standardised faculty training before implementation, use of validated assessment tools, collection of both quantitative and qualitative outcomes, and provision of the alternate intervention to all participants after data collection to ensure educational equity.

Limitations

The study has several limitations. It was conducted at a single centre with a relatively small sample size and evaluated only immediate post-test performance for one Biochemistry

competency. The educational design of the flashcard intervention emphasized flashcard construction rather than repeated retrieval practice, which may have underestimated the educational benefit of flashcards. Long-term knowledge retention and sustained learner experiences were not assessed. Future multicentric studies involving larger cohorts, multiple competencies, assessments for retention score calculation, and qualitative exploration of student's experiences are needed to establish the broader educational effectiveness of these learner-centred teaching-learning methods.

Conclusion:

Overall, the findings suggest that the jigsaw technique was an effective and preferred learner-centred strategy. Beyond improving immediate academic performance, it offers opportunities to develop communication, teamwork, leadership, and peer-learning skills, thereby aligning well with the goals of competency-based undergraduate medical education. Jigsaw learning demonstrated superior immediate learning outcomes and may be considered for conceptually challenging topics within CBME curricula.

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