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Original Article

Education Section

Transforming Medical Students from Passive to Active Learners: Introducing the Jigsaw Technique in Undergraduate Physiology Teaching

SUCHET TRIGOTRA[1], RUBY SHARMA[2], MANDEEP KAUR[3], SUPRIYA ARORA[4]

ABSTRACT

Introduction: Developing interpersonal, collaborative and teamwork skills in medical students from an early stage of their training is crucial for mastering the extensive medical curriculum and excelling in clinical practice. The Jigsaw (JS) teaching technique assigns each student in a group to learn and teach an equally important subtopic, ensuring active participation and promoting cooperative learning.

Aim: To evaluate the perceptions of students and faculty regarding the "JS" teaching-learning technique and to assess its effectiveness compared to the traditional didactic lecture method among first-year medical students in Physiology.

Materials and Methods: This educational interventional study was conducted at the Department of Physiology, Dr. B. R. Ambedkar State Institute of Medical Sciences, Mohali, Punjab, India, between May 2024 and July 2024, with 97 first-year medical students. Participants were divided into two groups: one exposed to the JS teaching-learning technique and the other to traditional didactic lectures. In the JS method, seven subtopics of a physiology competency were assigned to "parent" groups, which later formed "expert" groups for peer teaching. Two sessions were conducted on separate days with a crossover between groups. The study assessed knowledge acquisition through pre- and post-test scores and perceptions through validated feedback questionnaires. Statistical analysis included paired and independent sample t-tests for test score comparisons, with a p-value of <0.05 considered significant.

Results: All 97 participants (38 males, 59 females; mean age: 19.94±1.33 years) completed the study. The majority (89.67%) of students reported that the JS activity improved their communication skills and provided opportunities for team members to share information with one another. Students felt the method enhanced their peer teaching skills, analytical ability, interest in learning physiology and that they became more confident through active peer discussions. Both JS and traditional methods resulted in a statistically significant improvement in pre- and post-test scores ($p<0.001$).

Conclusion: Students in the present study expressed that working as a team in the JS technique enabled them to grasp topics more efficiently, facilitated deeper understanding through active peer discussions and fostered a sense of accomplishment. Such interactive, student-centred teaching-learning methods can be particularly valuable in the early years of medical training, transforming passive learners into active, engaged participants in their own education.

Keywords: Cooperative learning, Jigsaw teaching, Knowledge, Peer teaching, Perceptions

INTRODUCTION

Since the implementation of a competency-based medical curriculum in India, a variety of innovative teaching and learning methods have been explored. The National Medical Commission (NMC) emphasises a student-centric approach to teaching and learning while promoting self-directed learning to help fulfil the role of the Indian Medical Graduate (IMG) as a lifelong learner [1].

The "Jigsaw (JS)" teaching-learning method is an active learning strategy designed to engage students. This technique involves dividing the subject matter into segments, assigning each segment to a group of students and then encouraging them to collaboratively piece together the information to form a comprehensive understanding [2]. By requiring each student to actively participate, the method ensures that every learner plays a crucial role.

Physiology, a core subject in the first phase of the MBBS curriculum, necessitates active student engagement to grasp and retain complex physiological concepts and their clinical applications. To address this need, incorporating active teaching and learning techniques like the JS method into physiology training can enhance students' understanding of the subject.

Given the vast medical curriculum and the demands of clinical practice, collaborative, cooperative and team-based learning approaches have become essential [3]. It is crucial to cultivate interpersonal, collaborative and teamwork skills in medical students from the early stages of their training [4,5]. The JS technique fosters cooperative learning by requiring students to become active learners who teach their peers, thereby promoting teamwork and collaboration.

In most previous studies, the JS technique was applied after the topic had been taught through traditional large-group teaching methods [4,6,7]. In contrast, the present study selected new topics from the core competencies of physiology that had not been previously taught using any method for the JS sessions.

The aim of the present study was to assess the perceptions of undergraduate medical students and faculty regarding the "JS" teaching-learning technique and to evaluate its effectiveness in comparison to the traditional didactic lecture method.

MATERIALS AND METHODS

This educational interventional study was conducted in the Department of Physiology at Dr. B. R. Ambedkar State Institute of

Medical Sciences, Mohali, Punjab, India, over three months (May 2024-July 2024). The study received approval from the Institutional Ethics Committee as an exempt study (vide Letter No. AIMS/IEC-HR/2024/08, dated 8th May 2024).

Inclusion criteria:

- First-year Bachelor of Medicine Bachelor of Surgery (MBBS) students of Batch 2023;
- Students who attended both sessions (pretest and post-test included).

Exclusion criteria:

- Students who missed either the pretest or post-test;
- Students who did not provide consent to participate in the study.

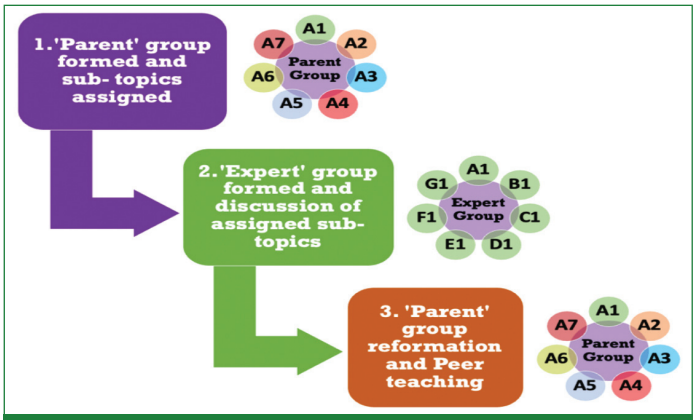
Sample size: The study enrolled 97 first-phase undergraduate medical students. The participants (N=97) were divided into two main groups. One group (Group 1) was exposed to the JS teaching-learning technique, while the other (Group 2) received traditional didactic lectures. A crossover design was employed, where the groups switched methods for the second session to ensure equitable exposure to both techniques.

Study Procedure

Preparation and sensitisation: Students were sensitised to the JS technique two days before the first session. The study's purpose and procedures were explained in detail to the students before enrolling them in the study. Training on this new technique was also provided to the faculty and tutors involved from the Physiology and Biochemistry departments. The sensitisation sessions for the JS technique were conducted by the first author, the principal investigator of the current study and a member of the medical education unit.

Session details: The students were randomly divided into two main groups: one group was exposed to the JS technique, while the other received traditional didactic lectures. Two sessions were conducted one week apart, with a crossover of groups in the second session. Two core competency topics from the Physiology curriculum were chosen for the JS technique: Hypothalamus for Session 1 and Mineralocorticoids for Session 2.

- **Session 1:** Group 1 (n=49) participated in the JS technique for the Hypothalamus and was further divided into seven "parent groups" (A-G), with seven students in each. The students in Group 1 were assigned subtopics and those with the same subtopic formed "expert groups." The expert groups discussed their subtopics for 20-30 minutes before returning to their parent groups, where they taught their peers for 15-minute intervals. Simultaneously, Group 2 (n=48) received a didactic lecture on the same topic (as illustrated in [Table/Fig-1]). After the session, students completed an anonymous feedback questionnaire assessing the JS technique.



[Table/Fig-1]: Key steps for the Jigsaw (JS) technique.

- **Session 2:** After one week, a crossover was implemented. Group 2 participated in the JS technique for Mineralocorticoids, while Group 1 attended a didactic lecture on the same topic. A total of 10 Multiple-choice Questions (MCQs), worth one mark each for both topics separately, were prepared by the first author and validated by faculty from the Physiology department. The students were asked to complete MCQ-based pretests and post-tests using Google Forms for both sessions.

Data collection and feedback:

- **Knowledge assessment:** Pre- and post-tests (MCQs) were conducted for both topics just before and after each session.
- **Student feedback:** A validated feedback questionnaire with 10 statements on a Likert scale, along with two open-ended questions, was designed to assess student perceptions of the JS technique. The questionnaire was meticulously designed by the first author and underwent a peer-validation process to ensure both content and construct validity. This validation process included a review and feedback from three subject experts in medical education and physiology to assess the relevance, clarity and comprehensiveness of the items. Modifications were made based on their suggestions to improve question phrasing and alignment with the study objectives. The revised questionnaire was then pilot-tested on a small group of students (not included in the study) to confirm its reliability and ease of understanding before its final implementation.

  The Satisfaction Index (SI) for each statement using the Likert scale was calculated using the following formula [4]:

$$SI=\frac{1\,(n1)+2\,(n2)+3\,(n3)+4\,(n4)+5\,(n5)}{N\times5}\times100$$

  where n1 to n5 represent responses ranging from "strongly disagree" to "strongly agree," and N is the total number of responses.
- **Faculty feedback:** An anonymous open-ended questionnaire with five questions (merits, demerits, feasibility, suggestions and impact) was used to capture faculty perceptions of the JS technique. The questions in the questionnaire were grouped into 'merits', 'demerits' and 'suggestions' due to overlapping comments from faculty members. A comparison of the qualitative data from feedback was also conducted between students and faculty.

STATISTICAL ANALYSIS

The responses to the pre- and post-tests, as well as the feedback forms, were entered into Excel sheets. Only those students who completed both the pre- and post-tests were included in the analysis. The data was found to be normally distributed, allowing for the use of parametric tests for analysis. Descriptive statistics, including proportions and means, were calculated for the pre- and post-test scores. A paired sample t-test was used to compare the pre- and post-test scores within the same group, while an independent (unpaired) sample t-test was applied to compare the scores between the JS and didactic lecture groups. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 97 undergraduate first-phase students (38 males and 59 females) with a mean age of 19.94±1.33 years participated in the JS sessions of the study, having no prior experience with the JS technique. Out of the total 97 students, 49 (19 males and 30 females) participated in the first session, while 48 (19 males and 29 females) participated in the second session.

A statistically significant improvement ($p<0.001$) in scores was observed in both the pre- and post-MCQ tests for the JS and didactic lecture methods across both sessions [Table/Fig-2]. These

results demonstrate that the participants' knowledge of completely new topics improved following the sessions.

Day and topic	Group	Pre-test score Mean±SD	Post-test score Mean±SD	p-value (paired t-test)
Day 1 Topic-1	JS Technique (n=49)	3.73±2.65	7.85±2.87	<0.001
	Didactic Lecture (n=47)	3.70±2.12	7.57±2.33	<0.001
Day 2 Topic-2	JS Technique (n=47)	3.44±4.03	6.93±3.58	<0.001
	Didactic Lecture (n=43)	3.53±4.01	6.79±0.16	<0.001

[Table/Fig-2]: Pre-test score versus post-test score within the groups by paired t-test.
n=47 in Group 2 of Session 1, as analysis was conducted on pre- and post- test scores for 47 students, with one student excluded due to missing post- test data

The absolute gain in mean scores between the two sessions conducted using the JS technique and the traditional didactic lecture method is compared in [Table/Fig-3]. While the JS technique showed slightly higher score gains compared to traditional lectures, the difference was not statistically significant (p-values of 0.42 for topic 1 and 0.37 for topic 2). This indicates that both teaching methods effectively facilitated knowledge acquisition.

After completing the activity, students provided feedback using a prevalidated questionnaire. The responses regarding the JS technique were presented with the number of students and corresponding percentages in brackets, based on a Likert scale. The SI for each statement was calculated and rated on a scale of 1-100. Statements 4, 5 and 9, which pertained to improvements in communication skills, peer interaction and teaching skills through the JS technique, achieved an SI of more than 80%. Student feedback from 97 students indicated that 87 students (89.67%) agreed that the activity helped

Topic	Group	Absolute gain in test score Mean±SD	p-value (unpaired t-test)
Topic-1	JS Technique (n=49) Didactic Lecture (n=47)	4.12±4.36 3.87±2.76	0.42
Topic-2	JS Technique (n=47) Didactic Lecture (n=43)	3.49±4.05 3.26±5.16	0.37

[Table/Fig-3]: Comparison between absolute gain in score by Jigsaw (JS) technique and didactic lecture method.
n=47 in Group 2 of Session 1, as analysis was conducted on pre- and post- test scores for 47 students, with one student excluded due to missing post- test data

improve their communication skills and provided opportunities for team members to share information. Similarly, 77 students (79.38%) felt the method enhanced their peer teaching skills, while 72 students (74.22%) agreed that it improved their analytical abilities and increased their interest in learning physiology [Table/Fig-4].

The core themes from the open-ended feedback responses regarding the JS technique are summarised in [Table/Fig-5]. Feedback from students (n=97) and faculty (n=9) aligned closely, indicating that the JS technique, as a cooperative and engaging teaching-learning method, helped students learn as a team through peer interaction. Students reported improvements in communication, teaching and analytical skills. They gained confidence from teaching their peers and acquired a deeper understanding of the topic through active discussion.

Students suggested allowing more time for the "expert" group to fully comprehend the new topic and recommended applying this method to topics already taught using traditional methods. Although students appreciated the fast-paced nature of the activity, faculty expressed concerns about the time-intensive nature of the entire process, noting that it might be more feasible as an occasional supplementary activity alongside regular teaching.

S. No.	Statements Number of students n (%)	Strongly disagree n1 (%)	Disagree n2 (%)	Neutral n3 (%)	Agree n4 (%)	Strongly agree n5 (%)	Satisfaction Index (SI) (%)
1	Has increased my interest in learning Physiology	3 (3.1%)	4 (4.12%)	18 (18.6%)	48 (49.48%)	24 (24.7%)	77.73
2	It has enabled in- depth understanding of the topic covered	4 (4.12%)	13 (13.4%)	11 (11.34%)	55 (56.71%)	14 (14.43%)	72.78
3	It has improved my analytical ability	3 (3.1%)	5 (5.15%)	17 (17.5%)	48 (49.48%)	24 (24.77%)	77.52
4	It has helped me to improve my communication skills	1 (1.03%)	1 (1.03%)	8 (8.24%)	48 (49.5%)	39 (40.2%)	85.97
5	It creates opportunities for team members to share information with others	1 (1.1%)	0 (0%)	9 (8.2%)	45 (46.4%)	42 (44.3%)	85.56
6	It can be applied for other concepts of Physiology in future	9 (9.3%)	13 (13.45%)	17 (17.5%)	37 (38.15%)	21 (21.6%)	71.95
7	It is an interesting way of learning	7 (7.3%)	9 (9.3%)	18 (19%)	34 (34.4%)	29 (30%)	74.22
8	I could easily adapt to this technique	3 (3.1%)	18 (18.53%)	20 (20.61)	31 (32%)	25 (25.77%)	71.75
9	It improves peer teaching skills in the participants	2 (2.2%)	4 (4.2%)	14 (14%)	43 (44.5%)	34 (35.1%)	81.23
10	I could learn quickly as a team by using this technique	9 (9.47%)	12 (10.53%)	26 (26.39%)	41 (43.21%)	9 (10.4%)	65.97

[Table/Fig-4]: Responses from students' feedback questionnaire regarding Jigsaw (JS) technique and Satisfaction Index (SI) of each statement (N=97 students).

Core ideas	From students (n=97)	From faculty (n=9)
Merits	1. Improves communication skills 2. Better teamwork and peer interaction 3. Improves teaching skills by peer cooperative teaching 4. Better understanding of given topic and improves analytic skills 5. Fast method of learning gained confidence	a. Improves peer interaction and enhances communication skills of students b. Students learn self-teaching skills, thus promotes self-directed learning c. Students acquire in-depth understanding by active discussion d. Fast way of learning a topic e. Students gain confidence by teaching their peers
Demerits	1. Less time was given during conduct of session i.e., session was time intensive 2. Where conceptual understanding of topic is concerned, faculty is able to explain better as compared to peers	a. Less time given to expert group b. Understanding of whole topic is affected in case of disinterested student c. Time consuming
Suggestions	1. More time should be given to expert group to prepare totally new topic 2. More effective for better understanding of topic already taught by traditional method	a. Should be applied to short subtopics b. More time, trained faculty and adequate space required for proper conduct of session c. Students should be provided multiple aids for teaching their peers like white board etc. d. It can be planned once in a while in between regular teaching

[Table/Fig-5]: Faculty and student responses to open-ended feedback questions on the Jigsaw (JS) technique as a teaching-learning method.

DISCUSSION

In the present study, the 'JS' teaching-learning technique was introduced to undergraduate medical students in physiology. The students' perceptions of the JS technique were highly satisfactory, as they worked collaboratively as a team, contributing equally to learning a topic and thereby fostering cooperative learning. The successful execution of two separate JS sessions with the support of nine faculty members from the physiology and biochemistry departments demonstrated that faculty need only to be well-versed in the methodology rather than being subject matter experts. This flexibility makes the JS technique feasible for collaborative implementation across departments, particularly in scenarios with limited faculty resources. It can also be incorporated into regular Small Group Discussions (SGDs) or tutorial sessions to break monotony and promote peer-assisted learning.

A majority of students (90%) reported that the JS activity improved peer interaction, communication and teaching skills, as supported by the high SI in our study. Additionally, improvements in analytical skills (75%) and in-depth understanding of the topic (71%) were also observed.

The present study findings align with those of Jeppu AK et al., who introduced the JS technique to first-phase medical students in 2023 and found that this cooperative learning method significantly enhanced communication, teamwork, critical thinking and positive interdependence during early medical training [3]. Similarly, in the present study, two new topics from the core competencies of physiology were taught using the JS technique over two sessions held one week apart. Pahwa AR et al., also employed the JS method to teach entirely new topics to second-year medical students, concluding that such student-centred, active learning strategies promote learning and foster learner autonomy and independence [8].

In contrast, Bhandari B et al., implemented a modified JS activity following conventional didactic lectures on selected topics in respiratory physiology, conducting four sessions over three weeks [4]. Their study yielded positive feedback, with students describing the JS method as an engaging and effective way of interacting with peers and enhancing learning.

In the present study, although the absolute gain in mean scores between the JS and traditional lecture methods was not statistically significant, both methods were effective in teaching new topics. Chauhan A et al., also compared these two methods in teaching the Attitude, Ethics and Communication (AETCOM) module to Phase I MBBS students [5]. They reported that the JS method was more effective in improving communication, teaching, analytical and time management skills.

Consistent with the present findings, Soundariya K et al., and Kumar CS et al., noted that the JS technique encouraged active participation and enhanced students' communication skills [9,10]. However, they also observed that it was time-consuming, which may explain why this method is infrequently used in routine curricula.

The JS technique emphasises peer teaching and learning, whereby every participant is accountable for both self-learning the assigned topic and teaching it to peers. This approach underscores the importance of teamwork and cooperative learning. Goolsarran N et al., highlighted that the JS method facilitates peer teaching and minimises resource requirements by reducing the need for multiple faculty facilitators [11].

Several studies have demonstrated that the JS technique can effectively engage medical students across various MBBS subjects, promoting collaborative learning [12-14]. Gowda VBSR et al., and Ng P et al., compared pre- and post-test scores using the JS technique and other teaching methods, reporting significant knowledge gains with the JS approach [15,16].

The 'JS' teaching-learning technique was well-received by both students and faculty in our study. This method effectively enhances students' knowledge, confidence, communication and teaching skills, transitioning them from passive to active learners. However, disengaged students can make the sessions less interactive, potentially affecting the overall learning process. To optimise its impact, this method can be applied more effectively to previously taught topics in a structured manner as part of SGDs.

Limitation(s)

The time allotted to students in the 'expert' group to learn and understand the entirely new topic was relatively short for their in-depth preparation of the assigned topic. Additionally, the proper conduct of sessions requires adequate infrastructure, including sufficient space and multiple teaching aids, such as whiteboards or digital tools, during peer-teaching sessions. Our study did not assess the long-term outcomes of the JS method, such as the retention of newly acquired knowledge over time, nor did it evaluate its application in enhancing clinical reasoning or problem-solving skills. Further research should explore these aspects and assess the effectiveness of the JS teaching-learning method in other departments and diverse subject areas.

CONCLUSION(S)

The 'JS' teaching-learning technique is an effective and innovative approach to improving students' communication, teaching and analytical skills. By fostering cooperative learning, the JS method highlights the importance of teamwork, wherein each student takes responsibility for their own learning and contributes to the collective understanding of the group. Students in the present study expressed that working as a team enabled them to grasp topics more efficiently, facilitated a deeper understanding through active peer discussions and helped them feel more confident. Thus, interactive teaching-learning methods like the JS technique should be introduced in undergraduate medical education to make budding doctors active learners during the early years of their medical training. Further work on the JS technique would provide a more holistic understanding of its utility and scalability across the medical curriculum.

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PARTICULARS OF CONTRIBUTORS:
1. Professor and Head, Department of Physiology, Dr. B. R. Ambedkar State Institute of Medical Sciences, Mohali, Punjab, India.
2. Associate Professor, Department of Physiology, Dr. B. R. Ambedkar State Institute of Medical Sciences, Mohali, Punjab, India.
3. Assistant Professor, Department of Physiology, Dr. B. R. Ambedkar State Institute of Medical Sciences, Mohali, Punjab, India.
4. Assistant Professor, Department of Physiology, Dr. B. R. Ambedkar State Institute of Medical Sciences, Mohali, Punjab, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Suchet Trigotra,
Professor and Head, Department of Physiology, Dr. B. R. Ambedkar State Institute of Medical Sciences, Mohali-160055, Punjab, India.
E-mail: suchet.dr@gmail.com

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