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Original Article

Effectiveness and Utility of Team-Based Learning in Teaching Integrated Competencies in Pharmacology: A Randomized Comparative Crossover Study

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Abstract

Background: The competency-based medical education (CBME) curriculum of India insists on a greater number of active learning sessions to teach integrated competencies. Self-directed learning (SDL) is a commonly used active learning session for a large number of students, whereas team-based learning (TBL) is a relatively untested approach in Indian medical schools.

Objectives: The aim of this study was to evaluate the effectiveness and utility of TBL sessions in teaching integrated pharmacology competencies within the CBME curriculum, and to assess student reactions and satisfaction with TBL.

Methods: We conducted a randomized crossover study among 87 second-year MBBS students at AIMSR, Chittoor, India, to assess the utility and effectiveness of TBL and SDL in teaching integrated pharmacology competencies. Pre- and post-test scores were compared using paired and unpaired t-tests, and student satisfaction with TBL was evaluated using a 5-point Likert scale via a digital questionnaire.

Results: The post-test performance of the TBL group was significantly higher than both its pre-test performance ($P = 0.0001$) and the post-test performance of the SDL group ($P = 0.004$). In contrast, there was no significant difference between pre- and post-test scores in the SDL group. Furthermore, student reactions and satisfaction with TBL were strongly positive.

Conclusion: Our findings indicate that TBL sessions are more effective than SDL sessions as active learning strategies, and that TBL can be successfully implemented in Indian medical colleges to teach integrated pharmacology topics within the CBME curriculum.

Keywords: Team-Based Learning (TBL); Self-Directed Learning (SDL); Integrated Curriculum; Pharmacology; Active Learning Sessions

Background

An active learning curriculum enhances both fellows' knowledge and faculty teaching skills (1). Medical educators have recognized the importance of active learning strategies such as small group teaching (SGT), problem-based learning (PBL), case-based learning (CBL), team-based learning (TBL), self-directed learning (SDL), small group discussions (SGD), student seminars, flipped classrooms (FC), and quizzes. Recently, the Indian medical education system has shifted from traditional teaching to competency-based medical education (CBME). The National Medical Commission (NMC) of India mandates a greater number of active learning sessions alongside didactic lectures in the CBME curriculum. Conventional pharmacology teaching methods are inadequate in developing students' reasoning skills. CBME emphasizes reducing rote memorization and adopting active learning strategies that foster critical thinking among students (2, 3).

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To facilitate active learning, SGT and PBL sessions are being adopted worldwide. In Indian medical schools, however, SGT and PBL are often not feasible due to an inadequate teacher–student ratio; therefore, SDL sessions are more commonly used. TBL may serve as a better tool to promote active learning in this context. The CBME curriculum consists of several integrated competencies, and TBL can be effectively combined with didactic lectures to teach these competencies. The key components of TBL include carefully formed and managed teams, pre-class preparation, individual readiness assurance tests (IRAT), group readiness assurance tests (GRAT) with scratch cards, problem-solving activities, peer evaluation, clinical problem-solving exercises, and timely feedback (4, 5). In TBL, student teams are actively engaged in brainstorming and applying concepts tested in the IRAT. Globally, a growing number of healthcare faculties have adopted TBL, and it has shown greater effectiveness in teaching complex subjects such as pharmacology, which requires integration with clinical therapeutics. Although SDL is mandated nationwide in the CBME curriculum, its effectiveness must be evaluated in comparison with other active learning strategies such as TBL.

I e typical class size in Indian medical schools is 150 students or more, making SGT and PBL sessions largely unfeasible. To facilitate active learning in large classes, TBL and SDL can be adopted, with TBL potentially offering greater benefits than SDL (6). In India, pre- and paraclinical subjects are usually taught away from the clinical setting, which prevents students from effectively connecting content delivered through didactic lectures with clinical applications (7). Within the CBME curriculum, many pharmacology competencies need to be integrated with other subjects, particularly general medicine. TBL and SDL sessions, when combined with lectures, may provide a more effective means of teaching such integrated competencies in medical schools with high student–teacher ratios. However, the effectiveness of TBL and SDL in teaching integrated competencies in Indian medical schools with large class sizes has not been adequately reported. Hence, this study was planned to evaluate the utility and effectiveness of TBL sessions in teaching integrated pharmacology competencies in comparison with SDL.

Objectives

To evaluate the effectiveness and utility of TBL and SDL sessions in teaching integrated pharmacology competencies within the CBME curriculum.

To assess student reactions and satisfaction with TBL

Methods

Design and setting: A randomized comparative crossover study was conducted among second-year MBBS students at the Apollo Institute of Medical Science and Research (AIMSR), affiliated with NTR Health Sciences University, Chittoor, India. Ethical approval was obtained from the AIMSR Research Ethics Committee (Ref: IEC17/AIMSR/05/2019). TBL sessions were conducted in a soundproof auditorium equipped with audiovisual aids and round tables, while SDL sessions were conducted in a lecture hall. Pretests (IRAT) and post-tests were conducted in the examination hall.

Components of TBL: Carefully formed teams (five students each) comprising a diverse mix of students were provided with study material and specific learning objectives (SLOs) on integrated topics one week prior to the session for preparation. An IRAT with well-structured five-option MCQs was conducted, followed by guided team-based problem-solving activities (brainstorming) and a GRAT using scratch cards. Frequent and timely feedback was provided on selected integrated concepts. Finally, each session concluded with a clinical problem-solving exercise based on a well-structured clinical case with structured questions (4, 5).

Participants: The sample size was calculated using the formula $N = (Z\alpha/2 + Z\beta)^2 \cdot \sigma^2 / d^2$, where N is the required number of participants, $Z\alpha/2$ is the Z-value for the desired significance level (1.96 for 5% significance, two-tailed), $Z\beta$ is the Z-value for the desired power (0.84 for 80% power), σ is the standard deviation of the within-subject difference (TBL – SDL) = 10, and d is the expected mean difference (effect size) between TBL and SDL = 5. By substituting these values, $N = 31.36$, which was rounded up to 32 per group (total sample size = 64). Each study group, however, consisted of more than 40 participants.

All participants were fully informed about the study objectives. Participation was voluntary, and there was no penalty for declining. The study was conducted among 2nd MBBS students. Of 150 eligible students, 87 provided consent and participated. Students were randomly assigned to TBL (n = 41) and SDL (n = 46) groups (Figure-1). Within the TBL group, students were further divided into 8–9 teams, ensuring diversity in academic performance (high, medium, and low performers) and gender distribution (5).

First stage of the study: Three faculty members from the Department of Pharmacology were involved in preparing the study material, specific learning objectives (SLOs), and MCQs, as well as implementing the TBL

and SDL sessions. Study material on recent trends in the management of diabetes mellitus, along with SLOs, was provided to students two weeks in advance for pre-class preparation.

Ten well-structured higher-order MCQs (designed to assess analysis, application, and evaluation skills), each with five options, were constructed and used to conduct a pre-test (IRAT) prior to the TBL/SDL sessions. In the TBL group, each team received one scratch card (Figure 2) along with the MCQs used in the IRAT. Teams were instructed to brainstorm the concepts tested in the IRAT for 40 minutes and then reattempt the same MCQs (GRAT) by scratching the correct option on the provided scratch cards. While designing the MCQs, correct options were aligned with the scratch card key. Scoring was based on the number of attempts: first scratch = 10 marks, second scratch = 7 marks, third scratch = 4 marks, fourth scratch = 1 mark, and fiNh scratch = 0 marks.

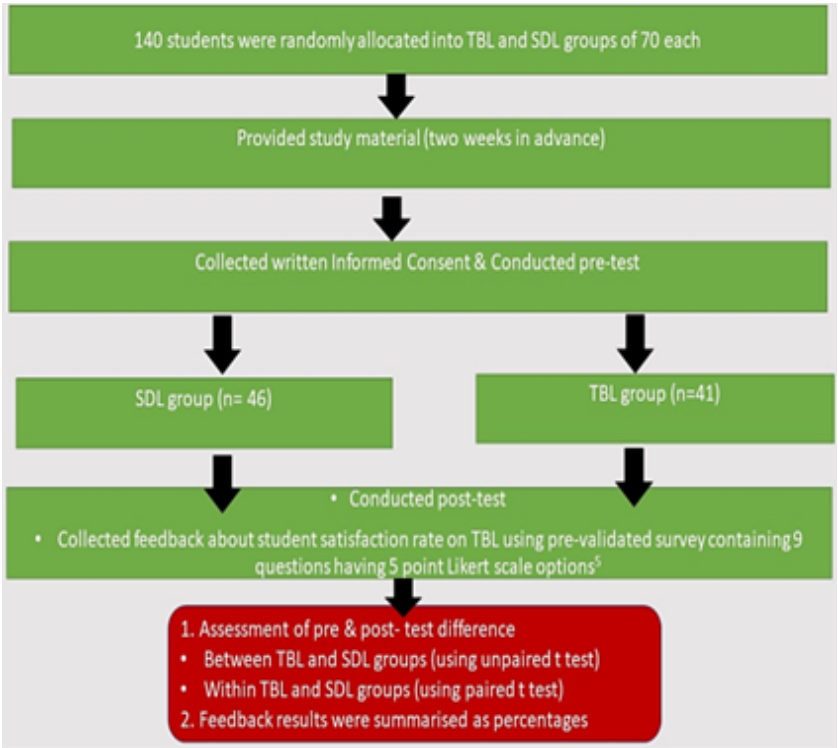

Figure 1. Flow chart of the study

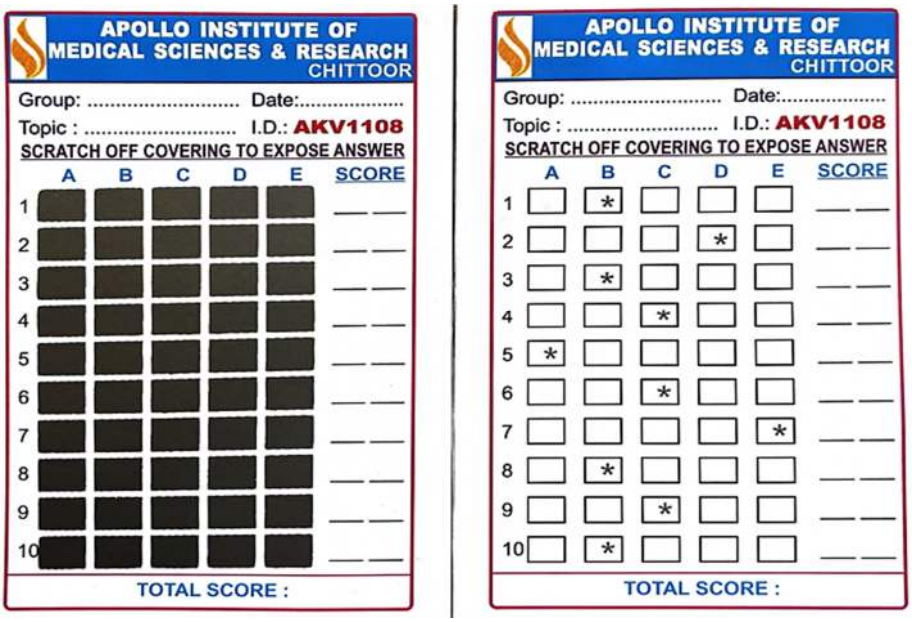

Figure 2. Scratch card: First scratch correct answer fetches more marks and subsequent scratches fetch less marks (1st scratch -10 marks, 2nd scratch-7 marks, 3rd scratch-4marks, 4th scratch -1 marks, 5th scratch -0 marks and total marks-100)

After collecting the scratch cards, the MCQs were projected on the screen, and students—especially from teams that did not perform well—were randomly selected to explain the rationale for correct and incorrect options. Simultaneously, frequent and timely feedback was provided on selected integrated concepts. Each session concluded with a clinical problem-solving activity based on a well-structured clinical case with structured questions.

Students in the SDL group were seated in a separate classroom, where they prepared the topic independently under the supervision of one faculty member. On the following day, a post-test was conducted for both TBL and SDL groups using slightly modified MCQs.

Second stage of the study: Students in the TBL group during the first stage were crossed over to the SDL group, and vice versa. Study material on recent trends in the management of chronic asthma, along with specific learning objectives (SLOs), was provided two weeks in advance for pre-class preparation. The rest of the procedures were similar to those followed in the first stage of the study.

Survey with a digital questionnaire: To assess student reactions and satisfaction with TBL, we used a modified, pre-validated survey consisting of nine questions on a 5-point Likert scale (8). Questionnaires employing Likert scales are useful for evaluating various aspects of a program, including overall satisfaction, specific course elements, and the learning environment.

This specially designed survey instrument assessed whether students would recommend TBL to their peers, whether the TBL module enhanced their understanding of the integrated topic, improved their self-directed learning skills, encouraged participation, or created barriers to learning. It also evaluated whether students were more satisfied with student-led TBL sessions, whether TBL should be incorporated into core curricular classes, whether they gained a better understanding of TBL pedagogy, and whether they felt they had successfully achieved the learning outcomes of the integrated topic. A total of 82 students participated in this survey using the 5-point Likert scale.

Data Analysis: Data were analysed using the Statistical Package for the Social Sciences (SPSS), version 26. Differences between pre- and post-test scores within each group, as well as between the TBL and SDL groups, were assessed using paired and unpaired *t*-tests. A *p*-value of <0.05 was considered statistically significant. Student satisfaction with TBL was analysed using descriptive statistics and expressed as percentage distributions, which were presented in pie charts.

Results

The pre-test difference between TBL and SDL was (–0.72), which was not significant (p = 0.55). However, the post-test difference between TBL and SDL was 1.02, which was highly significant (p = 0.004), indicating that TBL may be a more effective active learning strategy than SDL for teaching complex and integrated pharmacology competencies. The pre- to post-test difference in the TBL group was –1.95, which was highly significant (p = 0.0001), whereas in the SDL group the difference was –0.22, which was not significant (p = 0.53). I ese results suggest that SDL is less effective as an active learning strategy, while TBL is more effective and should be incorporated alongside SDL in Indian medical schools, where the CBME curriculum has been recently introduced (Table 1) (Figure 3 A-D).

Analysis of a digital questionnaire using a 5-point Likert scale demonstrated high student satisfaction with TBL as a teaching methodology. Student satisfaction rates exceeded 90% across all feedback questions (Figure 4 A-I).

Table 1. Pre-test and post-test score differences between and within TBL and SDL groups

Group	Mean	SD	Mean difference	P value
Pre-test difference between TBL and SDL (using unpaired t-test)				
TBL	3.20	1.54	-0.72	0.55
SDL	3.92	1.91		
Post-test difference between TBL and SDL (using unpaired t-test)				
TBL	5.15	2.03	1.02	0.004
SDL	4.13	1.94		
Pre-test and post-test difference in TBL group (using paired t test)				
Pre-test	3.20	1.54	-1.95	0.0001
Post-test	5.15	2.03		
Pre-test and post-test difference in SDL group (using paired t test)				
Pre-test	3.91	1.90	-0.22	0.53
Post-test	4.13	1.91		

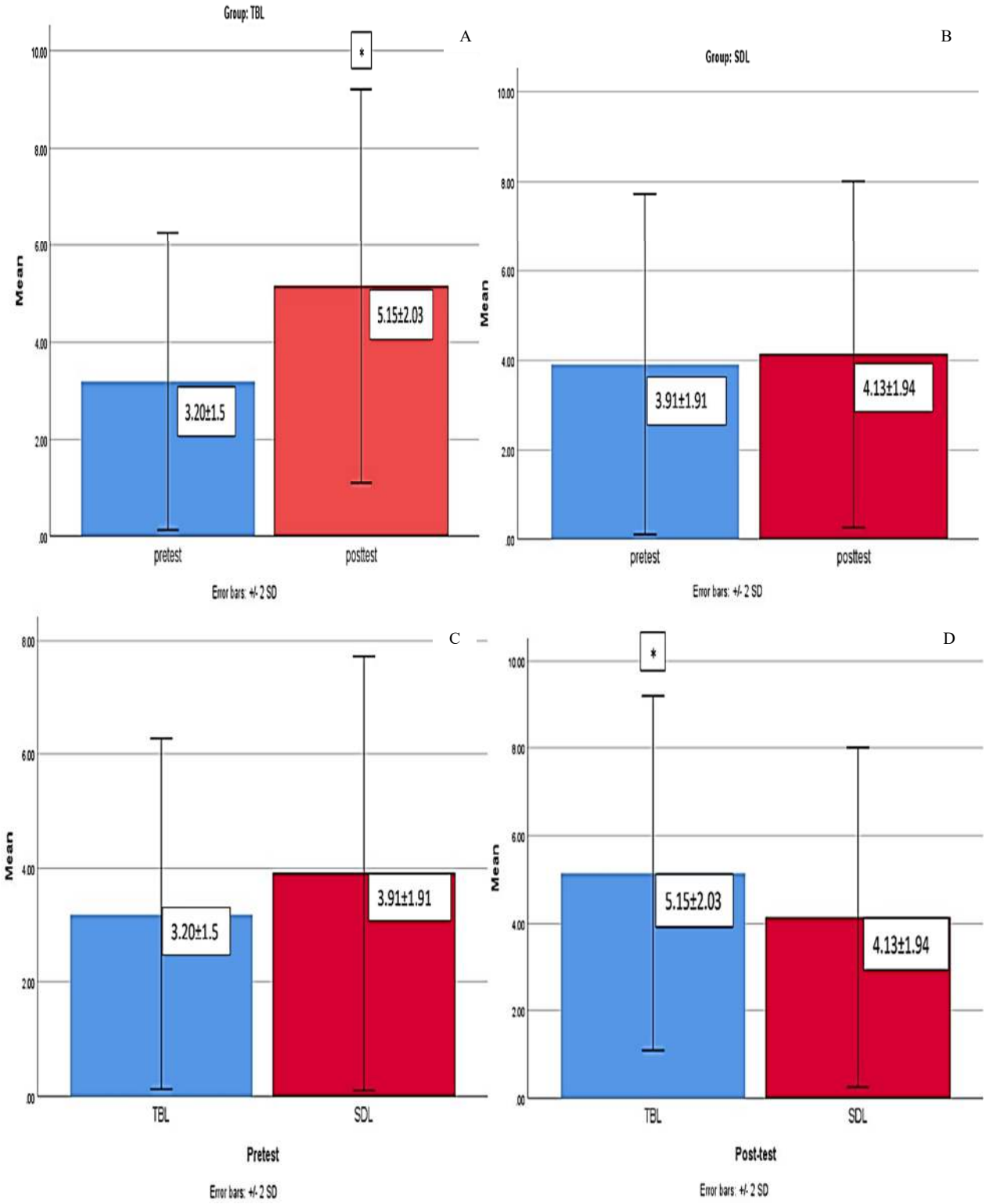

Figure 3. A: Pre-test and post-test score difference in TBL group (using paired t test) [*indicate p less than 0.05 (0.0001)]; B: Pre-test and post-test score difference in SDL group (using paired t test); C: Pre-test score difference between TBL and SDL groups (using unpaired t-test); D: Post-test score difference between TBL and SDL groups (using unpaired t-test) [*indicate p less than 0.05 (0.004)]

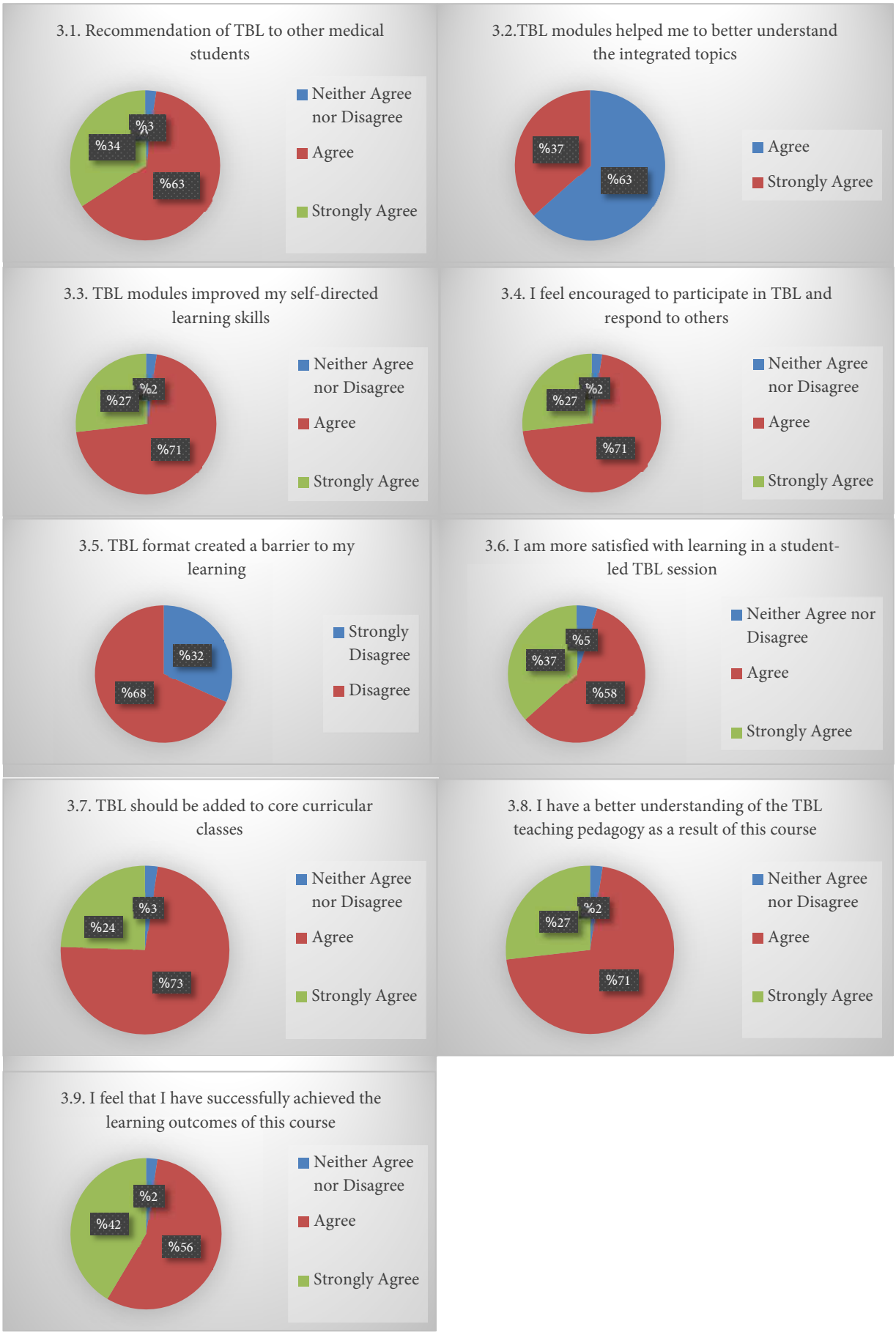

Figure 4. Student reaction and satisfaction rate on TBL- Modified pre-validated survey, containing nine 5 point-Likert scale questions

Most participating students indicated that they would recommend TBL to other medical students. They reported that the TBL module enhanced their understanding of the core concepts improved their self-directed learning skills, encouraged active participation, increased satisfaction with student-led learning, motivated them to include TBL in core curricular classes, deepened their understanding of the TBL pedagogy, and helped them successfully achieve the stated learning outcomes of the competency. Furthermore, students did not perceive the TBL format as a barrier to learning. These findings suggest that TBL may be the most appropriate active learning strategy and should be incorporated into all medical schools in India.

Discussion

The post-test performance of the TBL group was significantly higher than both its pre-test performance and the post-test performance of the SDL group, whereas there was no significant difference between pre- and post-test scores in the SDL group. In addition, student reactions and satisfaction with TBL were strongly positive. As our focus was on TBL, student reactions and satisfaction with SDL were not evaluated. Small groups of students working in teams are frequently used in medical education to enhance active learning and to develop communication skills (9). PBL, TBL, and SDL are prime examples of such strategies. Although there are logistical challenges in conducting PBL and SGD sessions in Indian medical schools, TBL and SDL can be adopted effectively and used in conjunction with lectures to teach integrated competencies. TBL is a student-centered yet instructor-led approach that enables one instructor to manage multiple small groups simultaneously, promoting interactive learning without requiring a large number of facilitators (10). In TBL, student teams are actively engaged in brainstorming and applying concepts tested in the IRAT. Our study demonstrates that TBL is an effective teaching strategy for integrated pharmacology topics and helps students improve performance, communication skills, and critical thinking.

SDL, on the other hand, is a process in which individuals take initiative—independently or with assistance—in diagnosing their learning needs, formulating goals, identifying resources, implementing strategies, and evaluating outcomes (11). With the introduction of CBME, SDL has gained increasing importance, as the curriculum mandates a certain number of SDL sessions in every subject and encourages students to view SDL as a lifelong learning strategy (12). However, our study suggests that TBL is more effective than SDL for teaching integrated pharmacology competencies. Despite this, the NMC does not mandate TBL sessions in the CBME curriculum. We strongly believe that the NMC should give greater attention to TBL and recommend implementing a certain number of TBL sessions in each subject to teach integrated competencies. TBL deserves more emphasis within the CBME curriculum (6). Regular TBL sessions may also foster SDL skills and lifelong learning strategies among students (13).

That said, TBL does involve logistical challenges, such as the need for a large, soundproof hall with audiovisual facilities, round tables and chairs for each team, scratch cards, and the additional workload for faculty (14). In contrast, SDL sessions are easier to conduct, requiring only a single faculty member in a lecture hall, and they may also promote lifelong learning attitudes (15).

Several studies comparing TBL with traditional teaching (16, 17) or with PBL (18) have reported higher ratings for TBL. Similarly, studies using TBL in pharmacology teaching observed that it enhanced understanding of complex concepts such as drug mechanisms of action, therapeutic uses, adverse effects, contraindications, and rational drug use (19, 20). Moreover, studies on clinical reasoning skills have shown that the addition of TBL sessions significantly improves clinical decision-making skills, indicating that TBL may be an appropriate method for teaching clinical decision-making. TBL groups scored higher and showed better retention of applied knowledge (21). A review article on systematic meta-analyses of TBL indicates that TBL pedagogy enhances the quality of medical education (22). To our knowledge, no previous comparative studies of TBL versus SDL in medical subjects, including pharmacology, have been reported. Based on our results, we recommend that all medical colleges in India adopt TBL as an active learning strategy, not only for integrated pharmacology competencies but also for competencies in other subjects.

The strength of the present study lies in its meticulously planned and executed comparison of TBL and SDL for teaching complex objectives in pharmacology, undertaken for the first time. Our results may encourage medical schools to incorporate TBL into the CBME curriculum, particularly for teaching complex and integrated pharmacology competencies

The limitations of the present study include the lack of prior awareness of the TBL methodology among both students and faculty, underscoring the need for proper

training of both groups to conduct such studies more effectively. Furthermore, as no comparative studies of TBL and SDL in pharmacology are available in the literature, additional research is required to substantiate our findings.

Conclusion

The post-test performance of the TBL group was significantly higher than both the pre-test performance of the TBL group and the post-test performance of the SDL group. Moreover, student reactions and satisfaction rates regarding TBL were strongly positive.

We conclude that TBL sessions are more effective active learning strategies than SDL sessions and can be successfully implemented in Indian medical colleges to teach integrated topics in pharmacology as well as other medical subjects. However, further research is needed to thoroughly evaluate the superiority of TBL over SDL in teaching complex and integrated competencies in pharmacology.

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Conflict of interests: There is no conflict of interest.

Ethical approval: Ethical approval was obtained from the AIMSR Research Ethics Committee (Ref: IEC17/AIMSR/05/2019).

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