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Original Article

Education Section

Integrating Team-based Learning into the Microbiology Curriculum: Impact on Students' Performance and Feedback in a Quasi-experimental Framework

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ABSTRACT

Introduction: With the implementation of Competency-Based Medical Education (CBME), the need for interactive, learner-centred teaching strategies has increased. Team-Based Learning (TBL) fulfils this need by fostering active engagement and collaborative problem-solving.

Aim: To evaluate the effectiveness of TBL with conventional didactic lectures among second-year MBBS students in Microbiology.

Materials and Methods: This quasi-experimental study was conducted in the Department of Microbiology at Smt BK Shah Medical Institute and Research Centre, Vadodara, Gujarat, India over three months (March 5, 2025, to June 5, 2025), after Institutional Ethics Committee approval. A total of 182 second-year MBBS students who attended all TBL sessions on selected infectious disease topics were included. Learning outcomes were assessed using the Individual Readiness Assurance Test (iRAT), Team Readiness Assurance Test (tRAT), and post-session formative assessments. Student and faculty perceptions were collected using structured feedback questionnaires. Data were analysed using a paired t-test and descriptive statistics.

Results: Mean post-test scores were significantly higher after TBL (18.94±1.60) than after didactic lectures (13.13±2.68; p-value <0.0001). Post-test scores across all TBL sessions were higher than baseline iRAT scores, demonstrating significant improvement in immediate learning outcomes. Mean post-test scores were 19.02±1.45 for Urinary Tract Infections (UTI), 18.92±1.64 for skin and soft-tissue infections, and 18.88±1.63 for anaerobic infections/gas gangrene. Students reported that TBL enhanced engagement, motivation, conceptual clarity, and collaborative learning. Faculty also perceived TBL as a highly interactive and effective instructional strategy that improved participation and clinical reasoning.

Conclusion: TBL is an effective pedagogical approach that enhances learning outcomes and active engagement in undergraduate medical students. Integrating TBL into routine microbiology teaching can further support the successful implementation of CBME.

Keywords: Active learning, Competency-based medical education, Didactic lectures, Undergraduate medical education

INTRODUCTION

The TBL is an innovative, student-centred instructional strategy grounded in the principles of the flipped classroom. It is defined as an active learning and small-group instructional strategy that provides students with opportunities to apply conceptual knowledge through a sequence of activities that includes individual work, teamwork, and immediate feedback [1]. Developed by Professor Larry Michaelsen to address the challenges posed by increasing class sizes, TBL enables effective interactive learning even in large classrooms by promoting engagement, accountability, and structured group discussions [1,2]. The TBL framework encourages active learning, critical thinking, and teamwork through its readiness assurance process, application exercises, and real-time feedback. One of its major strengths is the ability to provide small-group learning experiences to large cohorts with limited faculty resources [2]. Numerous studies have demonstrated that TBL enhances cognitive outcomes, including knowledge retention, academic performance, and problem-solving skills. It has also been shown to improve clinical reasoning, communication, collaboration, and other non-technical competencies essential for medical practice [2]. Comparisons between TBL and other active learning approaches, such as Problem-Based Learning (PBL), indicate that while both promote deep learning and group interaction, TBL offers greater resource efficiency and standardisation, making it better suited for large groups [1,3]. However, successful implementation requires faculty training, adequate planning, and well-designed pre-class learning materials. In the Microbiology curriculum, teaching is traditionally delivered through PowerPoint-based didactic lectures, occasionally supplemented with videos. In our institution, the MBBS batch comprises approximately 250 students, posing challenges for interactive teaching and long-term retention using conventional lecture-based methods. The CBME curriculum emphasises higher-order skills such as critical appraisal, problem-solving, and self-directed learning-outcomes that conventional lectures alone fail to achieve effectively. Conventional lecture-based teaching in UG education often results in passive learning, limited student engagement, and suboptimal knowledge retention. This challenge is particularly visible in subjects like Microbiology, which require conceptual understanding and its clinical application. TBL, with its structured sequence of accountability-driven individual tasks and collaborative group activities, offers a promising alternative for enhancing engagement and learning outcomes in large cohorts [4,5]. The uniqueness of the present study lies in its holistic, comprehensive approach. Effective TBL sessions through multiple evaluation methods and feedback will improve the collaborative learning outcomes.

The present study was undertaken to evaluate the effectiveness of TBL compared to conventional lecture-based teaching among second-year MBBS students in Microbiology. The primary objective was to compare the immediate learning outcomes between the two teaching methods using post-test scores. The secondary objectives included assessing individual and team performance through iRAT and tRAT scores, as well as evaluating student and faculty perceptions regarding TBL as a teaching-learning strategy. It was hypothesised that students exposed to TBL would demonstrate significantly better learning outcomes and higher engagement compared to those taught by conventional lecture-based methods.

MATERIALS AND METHODS

A quasi-experimental educational intervention was conducted in the Department of Microbiology at Smt. BK Shah Medical Institute and Research Centre, Sumandeep Vidyapeeth, Gujarat, India among second-year MBBS students of the 2024-2025 academic batch over a period of three months, from March 5, 2025, to June 5, 2025. Ethical approval was obtained from the Institutional Ethics Committee of Sumandeep Vidyapeeth (Approval No. SVIEC/ON/Medi/RP/March/24159), and written informed consent was obtained from all participants before the study began.

A convenience sampling method was employed, wherein all eligible second-year MBBS students available during the study period were included. Students were initially divided into three groups (A, B, and C) based on institutional roll numbers, as per routine academic allocation. Within each group, smaller teams were formed using a stratified approach based on academic performance in the first internal assessment. Students were categorised as high performers (>70%), average performers (60-70%), and low performers (<60%). Each team comprised a balanced representation of all three categories to ensure heterogeneity and minimise selection bias. Of the 200 enrolled students, 182 students who attended the TBL sessions were included in the final analysis.

Inclusion criteria: All second-year MBBS students enrolled in the 2024-2025 academic year were included in the study.

Exclusion criteria: Students who were absent for more than one TBL session were excluded from the study.

The study was conducted as a time-bound educational intervention; hence, no formal sample size calculation was performed.

Recruitment and grouping: Students were initially divided into three groups (A, B, and C) based on roll numbers. In each group, students absent on that day were excluded from the study for each topic. One group underwent a TBL session. In contrast, the remaining groups attended conventional didactic lectures. Across the three topics, all groups were exposed to both TBL and conventional teaching methods, thereby allowing each participant to serve as their own control. Although 182 students were included in the study, the number of participants varied across sessions due to absenteeism on the day of the respective sessions [Table/Fig-1].

S. No.	Topic	TBL session (Demonstration room)	Conventional teaching*
1	Urinary Tract Infections (UTI)	60 students (Batch A, Roll no: 1-66)	120 students (Batches B and C)
2	Skin and Soft-Tissue Infections (Viral Exanthems and other viral cutaneous infections)	62 students (Batch C, Roll no. 133-200)	118 students (Batches A and B)
3	Overview of Anaerobic Infections and Gas Gangrene	60 students (Batch B, Roll no: 67-132)	100 students (Batches A and C)

[Table/Fig-1]: Distribution of TBL and conventional sessions was as follows.
*All students covered the same topics; however, the mode of instruction differed. The number of students varied across sessions due to absenteeism on the day of the respective sessions

Conventional teaching sessions were conducted as didactic lectures using PowerPoint presentations, with a duration comparable to TBL sessions (approximately 90-120 minutes). The same learning objectives were followed for both teaching methods. However, preclass preparatory materials were provided only for TBL sessions, as per its instructional design. All sessions were conducted by faculty members from the Department of Microbiology with prior orientation to the study protocol to minimise instructor-related variability. A convenience sample of 24 faculty members from five medical colleges who had prior experience with TBL implementation through the Advanced Course in Medical Education (ACME) programme were invited to participate. Faculty members who had implemented or were actively using TBL in their respective institutions were included. Their perceptions were collected using a structured feedback questionnaire to assess broader faculty perspectives regarding TBL

The TBL session was delivered in the following structured steps [4-6]:

1. **Preclass preparation:** Students received reading materials (PDFs, pre-recorded videos, and PowerPoint presentations) one week before each session. These resources were shared through student groups to facilitate baseline understanding of the assigned topic.
2. **Individual Readiness Assurance Test (iRAT):** Students completed a Google Form-based quiz comprising 20 validated case-based and factual MCQs within a 20-minute time limit. Each correct response was awarded one mark, with no negative marking. The iRAT served as a baseline (pretest) assessment of students' prior knowledge before the TBL intervention.
3. **Team Readiness Assurance Test (tRAT):** In each batch of 60 students, learners were further divided into 10 teams of six members each. Teams were formed using stratified sampling based on academic performance (internal assessment scores) to ensure balanced distribution of high (>70%), average (60-70%), and low performers (<60%) across teams, thereby minimising potential selection bias.
4. The same set of 20 MCQs used in the iRAT was administered again for collaborative discussion and group decision-making within a 20-minute limit. Team responses were recorded on answer sheets and collected for evaluation.
5. **Clarification and immediate feedback:** A 30-minute faculty-led interactive session was conducted to clarify misconceptions, reinforce key concepts, and discuss differential diagnoses. Immediate feedback strengthened conceptual understanding and addressed knowledge gaps.
6. **Application exercise (problem-solving activity):** Teams worked on structured clinical case scenarios relevant to the session topic (e.g., community-acquired and catheter-associated UTIs; gas gangrene; herpes; measles). Each team collaboratively analysed the case and answered higher-order application questions. A total of 40 minutes was provided for discussion and 20 minutes for presenting solutions. This phase encouraged critical thinking, diagnostic reasoning, and application of microbiological concepts.
7. **Discussion and closure:** Teams presented their solutions to the entire class, followed by facilitated discussion and cross-team comparison. This promoted deeper cognitive processing, peer learning, and the development of affective and collaborative skills. Faculty members guided the discussion and highlighted key learning points.
8. **Feedback collection:** Student feedback was obtained at the end of each session through Google Forms. Participants also summarised three key take-home messages before session closure.

9. **Formative assessment:** Post-tests were administered immediately after completion of each session to assess immediate learning outcomes. No formal washout period was implemented, as the interventions were part of routine academic scheduling. Here, 20 MCQs were given via Google Forms; they were different from the iRAT and tRAT questions. The questionnaire was scenario-based with the same difficulty level as iRAT and tRAT. The content validity of the questionnaire was assessed by two subject experts (Senior professors).
10. **Assessment of learning outcomes:** Performance was evaluated using iRAT scores, tRAT scores, and post-session formative assessments. Scores from TBL sessions were compared with post-test scores following conventional didactic lectures using paired t-tests.

Validation of Tools

MCQs: Validated internally by two senior Microbiology faculty members (one Professor and the Head of Department). The MCQs were designed to include a balanced mix of recall and higher-order application-based questions aligned with the learning objectives. Content validity of the MCQs was assessed using the Content Validity Index (CVI) method.

- **Feedback questionnaires:** Student and faculty feedback was collected using a structured questionnaire comprising Likert scale–based items (5-point scale: strongly disagree to strongly agree) and a few open-ended questions. The questionnaire assessed domains such as engagement, understanding, teamwork, and satisfaction. It was developed by the investigators and reviewed for content validity by a Curriculum Committee member and an MEU faculty member. The questionnaire was administered in English, and responses were analysed using descriptive statistics.

STATISTICAL ANALYSIS

Quantitative data were analysed using descriptive statistics (frequencies, means, and standard deviations). Paired t-tests were applied to compare post-test scores between TBL and conventional teaching. A p-value <0.05 was considered statistically significant. Effect size (Cohen's d) was calculated using the formula $d=t/\sqrt{n}$ to assess the magnitude of the difference.

RESULTS

Urinary Tract Infections (UTI) (n=60)

In the case of the first TBL session on UTI, the mean iRAT score was 9.90±3.08, reflecting the individual baseline understanding before team discussion. The mean TRAT score significantly increased to 18.33±1.86, indicating a great improvement due to team-based peer discussion and collaborative learning. The post-test mean score further improved to 19.02±1.45, showing a sustained gain in knowledge after the TBL session and facilitated debriefing [Table/Fig-2]. A statistically significant improvement was observed between iRAT and post-test scores (p-value=0.014), reflecting enhanced learning following the TBL session. The tRAT vs post-test comparison yielded a highly significant difference (t=3.65, p-value=0.0005), suggesting that team discussion followed by instructor-led clarification plays a crucial role in consolidating learning. The smaller standard deviation in post-test scores reflects a more uniform performance, possibly due to equal opportunity for clarification and knowledge synthesis during TBL [Table/Fig-2].

Skin and Soft Tissue Infections (Viral exanthems, etc.,) (n=62): In the second TBL session, the mean iRAT score was 9.97±3.50, reflecting students' baseline individual understanding before team discussion. Following collaborative learning during the tRAT, the mean score significantly increased to 17.68±1.97, highlighting the positive impact of peer interaction and group problem-solving. The mean post-test score further improved to 18.92±1.64, indicating sustained knowledge gain after the session and the benefit of instructor-led debriefing. Paired t-tests (iRAT vs post-test: t=-20.4, p-value <0.0001; tRAT vs post-test: t=-3.93, p-value=0.0003) confirmed that the observed improvements were statistically significant and educationally meaningful [Table/Fig-2].

Anaerobic Infections and Gas Gangrene (n=60): The average iRAT score was slightly better than in other sessions, but variability remained high. Post-discussion tRAT scores improved markedly, and the post-test scores reflected well-retained understanding. The paired t-tests again indicated strong statistical significance (iRAT vs post-test: t=-20.8, p-value <0.001; tRAT vs Post-test: t=-4.8, p-value <0.001 [Table/Fig-2].

The magnitude of improvement, as assessed by Cohen's d, ranged from small to large effect sizes. Moderate effect sizes were observed for tRAT to post-test comparisons, while larger effect sizes were noted between iRAT and post-test scores, reflecting cumulative learning during the TBL process [Table/Fig-2].

The mean score after TBL sessions (18.94) was significantly higher than that following conventional didactic lecture (13.13). A paired t-test yielded a t-value of 16.08 and a p-value <0.0001, indicating that the difference in scores between the TBL and Didactic methods is highly statistically significant. This implies that TBL is more effective in enhancing learning outcomes among students compared to traditional lectures [Table/Fig-3].

Most students expressed a strong preference for the TBL approach over conventional didactic lectures across all parameters assessed. Notably, 173 (95.1%) students felt TBL enhanced self-directed learning, while 170 (93.4%) reported that it motivated them to engage in preclass preparation, a key component of active learning. Furthermore, TBL was rated more effective in maintaining attention span (n=164, 90.1%), fostering conceptual understanding (n=155, 85.1%), and stimulating interest (n=161, 88.5%) during sessions. For doubt clarification, though the preference for TBL was less overwhelming, 113 (62.3%) vs. 69 (37.7%), the difference was still statistically significant (p-value=0.0112). Importantly, 167 (91.8%)

TBL session		Mean±SD	Comparison	p-value	Paired t-test	Cohen's d
Urinary Tract Infections (UTI) (n=60)	iRAT	9.90±3.08	iRAT vs Post-test	0.014	2.52	0.32
	tRAT	18.33±1.86	tRAT vs Post-test	0.0005	3.65	0.47
	Post-test	19.02±1.45	--	<0.0001	--	--
Skin and soft tissue infections (Viral exanthems and other viral cutaneous infections (n=62)	iRAT	9.97±3.50	iRAT vs Post-test	<0.0001	-20.4	2.59
	tRAT	17.68±1.97	tRAT vs Post-test	0.0003	-3.93	0.50
	Post-test	18.92±1.64	--	<0.0001	--	--
Overview of anaerobic infections and Gas gangrene (n=60)	iRAT	10.02±3.29	iRAT vs Post-test	<0.001	-20.8	2.68
	tRAT	17.58±2.04	tRAT vs Post-test	<0.001	-4.8	0.62
	Post-test	18.88±1.63	--	<0.001	--	--

[Table/Fig-2]: Comparison of mean scores (iRAT, tRAT, and post-test) across different TBL sessions.
Standard deviation represents the dispersion of values around the mean and is not bounded by the maximum score. As suggested, we assessed the normality of the data using the Kolmogorov–Smirnov test. The data were found to be normally distributed (p>0.05), and therefore, parametric tests (paired t-test) were appropriately applied

Group	M±SD	t-value (Paired)	p-value
TBL	18.94±1.60	16.08	<0.0001
Didactic Lectures (Conventional method)	13.13±2.68		

[Table/Fig-3]: Comparison of effectiveness of Team-Based Learning (TBL) with didactic lectures.

students recommended TBL as a suitable method for teaching must-know or core topics, indicating a high level of acceptance and satisfaction with the method. These findings suggest that TBL not only enhances engagement and comprehension but also promotes lifelong learning habits through peer collaboration and preclass preparation [Table/Fig-4].

S. No.	Questionnaire	Team-Based Learning (TBL), n (%)	Conventional didactic lectures, n (%)	p-value
1	Which method was more engaging and generated greater interest?	161 (88.5)	21 (11.5)	<0.0001
2	Which method helped maintain your attention span more effectively?	164 (90.1)	18 (9.9)	<0.0001
3	Which method better supported self-directed learning?	173 (95.1)	9 (4.9)	<0.0001
4	Which method helped you understand the concepts more clearly?	155 (85.1)	27 (14.9)	<0.0001
5	Which method helped clarify doubts better?	113 (62.3)	69 (37.7)	0.0112
6	Which method motivated you to prepare before the classroom session?	170 (93.4)	12 (6.6)	<0.0001
7	Would you recommend TBL as an effective teaching-learning method for core (must-know) topics?	167 (91.8) YES	15 (8.2) NO	<0.0001

[Table/Fig-4]: Students' perception about Team-Based Learning (TBL) and conventional didactic lectures (CDL).

The responses reflect a highly favourable perception of TBL among undergraduate MBBS students. A significant proportion, 76 (41.7%), believed that TBL collectively enhances multiple team-related competencies, such as adaptability, communication, peer interaction, and leadership. Although individual components received modest responses, the holistic appreciation of all the skills combined indicates that students recognise TBL as a powerful tool for interpersonal development [Table/Fig-5].

Feedback from 24 faculty members across medical colleges indicated strong support for the TBL methodology. Faculty unanimously viewed TBL as an effective, innovative pedagogy that enhances critical thinking and subject comprehension. Most of them agreed that it improves student engagement and faculty-student rapport, while iRAT/tRAT were considered valuable assessment tools promoting teamwork. Clinical application exercises were highly appreciated, with 19/24 (79.2%) strongly agreeing that they enhance clinical reasoning, aligning well with CBME goals. Additionally, 21/24 (87.5%) acknowledged their transition from lecturers to facilitators, and many emphasised the importance of interdisciplinary collaboration, aligning with the principles of CBME. Overall, faculty perceived TBL as positively transforming both teaching dynamics and student learning attitudes [Table/Fig-6].

An open-ended questionnaire regarding the challenges and limitations of the implementation of TBL was administered to all-the faculty. They identified several challenges in implementing TBL sessions, including the need for meticulous pre-planning, availability of suitable venues for small-group discussions, faculty sensitisation and training, and the time-intensive nature of session preparation and conduct. Student-related barriers included initial resistance due to

S. No.	Questionnaire	Frequency n (%)
1	**TBL enriches the team's skills by**	
	a. Learn to adapt within a team	13 (7.4)
	b. Gained opportunity to interact with unfamiliar peers	13 (7.4)
	c. Improved communication skills	13 (7.4)
	d. Recognised leadership opportunities	4 (2.2)
	e. Experienced enhanced team spirit	4 (2.2)
	f. All the above	135 (74.2)
2	**TBL helps to gain knowledge by**	
	a. Facilitated better comprehension compared to traditional lectures	76 (41.7)
	b. Promoted the development of problem-solving skills	61 (33.3)
	c. Enabled exposure to multiple perspectives for complex clinical scenarios	27 (14.8)
	d. Provided opportunities for peer teaching	18 (9.8)
3	**Impact on attitude**	
	a. Helped build confidence	119 (65.6)
	b. Encouraged open-mindedness	57 (31.1)
	c. No notable attitudinal change	6 (3.3)

[Table/Fig-5]: Student feedback on the effectiveness of TBL sessions (n=182).

S. No.	Feedback on TBL session	Response percentage- n (%)				
		5	4	3	2	1
1	TBL is an innovative teaching-learning method that enhances critical thinking among students	14 (58.3)	10 (41.7)	-	-	-
2	TBL enhances subject understanding better than conventional didactic lectures	13 (54.2)	11 (45.8)	-	-	-
3	TBL sessions help faculty strengthen their relationship with students	7 (29.2)	16 (66.7)	1 (4.2)	-	-
4	The Individual Readiness Assurance Test (iRAT) helps acquire foundational knowledge through pre-reading	10 (41.7)	14 (58.3)	-	-	-
5	The tRAT promotes teamwork and enhances collaborative learning	10 (41.7)	13 (54.2)	-	1 (4.2)	-
6	Application exercises in TBL promote clinical reasoning and discussion	19 (79.2)	5 (20.8)	-	-	-
7	TBL is more effective when co-facilitated by a paraclinical and a clinical faculty (Integration)	8 (33.3)	14 (58.3)	2 (8.3)	-	-
8	Faculty act more as facilitators rather than lecturers in TBL	21 (87.5)	2 (8.3)	1 (4.2)	-	-
9	TBL has the potential to influence student attitudes positively	13 (54.2)	10 (41.7)	1 (4.2)	-	-

[Table/Fig-6]: Feedback analysis of the faculty of the medical college: (n=24).
Likert scale response- (5-Strongly agree, 4-Agree, 3- Neutral, 2-Disagree, 1- Strongly Disagree)

unfamiliarity with the TBL format, absenteeism during examinations or institutional events, unequal participation within groups, and occasional demotivation. Suggested strategies to overcome these challenges included conducting faculty development programmes, orienting students to the benefits of TBL, incorporating innovative and clinically relevant case scenarios, careful lesson planning, trial runs with smaller groups, and providing counselling and confidence-building support when required [Table/Fig-7].

DISCUSSION

The present study appraised the effectiveness of TBL in comparison with conventional didactic lectures among undergraduate medical students and also evaluated the perceptions of students and faculty to incorporate TBL as a teaching-learning method. The findings demonstrated that TBL significantly enhanced student performance, engagement, and overall satisfaction, underscoring its value as

Challenges while implementing a TBL session	**For faculty:** a. Proper meticulous pre-planning b. Venue for the conduct of small group discussions c. Sensitisation of faculties d. Need trained faculty to conduct the sessions e. Time-consuming **For students:** a. Resistance by the students due to unfamiliarity with the format of TBL b. Student absenteeism either due to internal exams or due to annual day/week/sports day celebrations c. Inequality in participation d. Student demotivation
How will you overcome those challenges?	a. Conduct faculty development programmes b. Make the TBL session innovative and interesting, integrate clinical case scenarios to increase the relevance c. Start early, plan properly, and arrange a trial session with small groups to understand and rectify problems. d. Counselling of students if required e. Student orientation to TBL and explain its benefits f. Build their confidence g. Make the lesson plan

[Table/Fig-7]: Insights of the Medical faculty towards challenges in conducting TBL (Data collection via open-ended questionnaire).

an active learning strategy in the Microbiology curriculum. Across all three TBL sessions- UTIs, skin and soft tissue infections, and anaerobic infections- post-test scores were substantially higher than the iRAT scores, indicating notable knowledge gain after team discussion and faculty-led debriefing. The consistently higher tRAT scores underscore the role of peer learning and collaborative problem-solving in enhancing understanding. Similar findings have been reported by Jain AK et al., Dnyanesh S et al., Doshi N and Khan H et al., who demonstrated that TBL facilitates improved comprehension and retention through structured teamwork and guided reflection [5-8]. These findings are consistent with previous studies by Thistlethwaite JE et al., and Rajalingam P et al., they reported improved academic performance and enhanced learner engagement with active learning strategies such as TBL compared to conventional lecture-based approaches [9,10]. Doshi N also emphasised instructional strategies to teach students that facilitate active learning rather than one-way teaching during the lectures [7]. The backbone of TBL is self-directed learning, which is rightly reported by Doshi N [7]. In the present study, student feedback strongly favoured TBL, and most of the learners reported that TBL promoted self-directed learning (n=173/182, 95.1%), improved motivation for pre-class preparation (n=170/182, 93.4%), and enhanced attention span (n=164/182, 90.1%). These results corroborate the findings of Nawabi S et al., who described TBL as an approach that strengthens student accountability, conceptual clarity, and team dynamics [11].

In a study of TBL conducted by Jabbar H et al., and Govindrajan S and Rajaragupathy S, students liked the concept of learning the topics in stages, like iRAT, which not only helps them to prepare the concept beforehand but also encourages students to master the knowledge and objectives they are going to be assessed on [12,13]. If any deficiency is detected by the IRAT, it can be addressed by the tRAT through group discussion. Moreover, they felt that they learned from one another during discussions with their peers. Topics from the core area, which are covered in a one hour lecture session, and those taught in a defined sequence of TBL, also involving them, definitely would help the students to understand the concept well. In the present study, 113 (62.3%) students felt TBL clarified doubts better than lectures, a minority (n=69, 37.7%) still preferred traditional teacher-led instruction for certain foundational concepts.

According to the study by Jain AK et al., a substantial proportion of learners (>76%) reported that TBL supported better understanding of the allotted topic [5]. Positive student perceptions were also documented by Santana VC et al., Moore-Davis TL et al., Gray J et al., Bengü E, and Alwahab A et al., where the majority of participants acknowledged improved conceptual clarity after TBL sessions [14-18]. However, contrasting evidence was presented by Okubo Y et al., in which only a small minority of students regarded TBL as effective for enhancing topic comprehension [19]. Such differences across studies may be influenced by variations in learner characteristics, institutional settings, and implementation methods. This suggests that a blended teaching approach, incorporating both TBL and targeted didactic inputs, offers a more balanced and adaptable approach for heterogeneous student groups.

Faculty members' purview regarding TBL also echoes well with the findings of Bhadri GN and Patil LR and Joshi T et al., which state that TBL has the potential to enhance reflective learning, critical thinking in students, and also improve faculty-student rapport, and highlighted the shift from the role of lecturer to facilitators [20,21]. Also, expressed positive views regarding TBL implementation. Beyond cognitive gains, TBL fostered valuable non-cognitive competencies like team dynamics and skill development for medical practice. Students reported improvements in communication, leadership, adaptability, and teamwork, with 135 (74.2%) acknowledging benefits across all domains. Additionally, 119 (65.6%) reported increased self-confidence, while 57 (31.1%) students agreed that it enhances open-mindedness. These attributes align with the AETCOM module objectives advocated by the National Medical Commission, which emphasise holistic professional development.

The TBL creates a mutually beneficial educational environment in which both students and facilitators actively contribute to the learning process. It enables learners to discuss and analyse common as well as complex case scenarios, thereby improving knowledge acquisition, clinical reasoning, and academic performance. Similar benefits of active learning strategies have been highlighted in studies by Alizadeh M et al., Nair SK and Rai N, Vedi N and Dulloo P, and Cendan JC et al., [22-25]. In addition, peer evaluation, constructive feedback, and student reflections help strengthen professional collaboration among faculty members and promote continuous refinement of teaching practices.

Limitation(s)

Formal psychometric validation of the assessment tools was not undertaken, which may influence the reliability of the findings. The absence of a parallel control group and the use of different topics for TBL and conventional teaching restricted direct comparison between the two methods. Student feedback was based on post-session perceptions without a baseline assessment. Future studies with randomised designs, comparable content across teaching methods, and long-term retention assessment are recommended.

CONCLUSION(S)

The present study suggests that TBL is an effective and well-accepted instructional strategy for undergraduate Microbiology education. Students showed higher performance on topics taught via TBL. It was associated with improved immediate learning outcomes, greater student engagement, collaborative learning, and the development of important soft skills such as communication and teamwork. Positive perceptions from both students and faculty support its inclusion as a complementary teaching-learning approach within the routine curriculum.

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