

The Application of a Team-Based Learning Approach Enhances Students' Academic Performance

Mohamed M A E L Salem^{1,2,*}, Mohammed A M Salih^{1,3}, Hanin M M Salem⁴, Muhammad Shahid¹, Amjad Shahzad⁵

¹Department of Medical Sciences, School of Pharmacy, Optometry and Medical Sciences, Faculty of Health and Social Care, University of Bradford, ENGLAND.

²University of Bradford International College, University of Bradford, ENGLAND.

³Department of Health and Social Care, Scholars School System with Leeds Trinity University, ENGLAND.

⁴Department of Medicine, Aston Medical School, Health and Life Sciences Faculty, Aston University, Birmingham, ENGLAND.

⁵Department of Chemistry, University of Azad Jammu and Kashmir, King Abdullah Campus, Muzaffarabad, PAKISTAN.

ABSTRACT

Objectives: This study evaluated the implementation of a Team-Based Learning modified TBL approach in Biotechnology and Chemistry modules at the University of Azad Jammu and Kashmir and explored its impact on students' academic performance and perceptions. **Background:** Traditional lecture-based methods in higher education have faced criticism for limited effectiveness in engaging students and fostering critical thinking. The modified TBL approaches have increasingly been adopted in science education to promote collaborative learning and active participation. **Materials and Methods:** A quasi-experimental pre-test/post-test educational intervention study was conducted during the 2023/2024 academic year involving fourth-year Biotechnology and Chemistry students at the Faculty of Science, University of Azad Jammu and Kashmir. The same cohort of students participated in both pre- and post-intervention assessments. The modified TBL intervention included pre-class preparation materials, team-based discussions, and application-focused activities. Academic performance before and after the intervention was compared using paired statistical analysis. Student perceptions regarding the modified TBL experience were also collected using a structured post-lecture survey. **Results:** Students demonstrated significant improvement in post-course assessment scores following implementation of the modified TBL approach compared with traditional lecture-based teaching ($p < 0.05$). Survey responses indicated positive perceptions regarding student engagement, collaboration, preparation, and understanding of course content. Most students reported that the modified TBL sessions improved participation and promoted deeper learning. Data are presented as mean $\pm$ SD. Statistical analysis was performed using paired t-test ($*p < 0.05$). **Conclusion:** The findings suggest that modified TBL may enhance student engagement and academic performance in Biotechnology and Chemistry education. However, further studies using larger sample sizes, validated assessment tools, and long-term evaluation are required before broader curriculum-wide implementation.

Keywords: Active Learning, Biotechnology Education, Chemistry Education, Higher Education, Student Engagement, Team-Based Learning.

Correspondence:

Dr. Mohamed M A E L Salem

Department of Medical Sciences, School of Pharmacy, Optometry and Medical Sciences, Faculty of Health and Social Care, University of Bradford, ENGLAND. University of Bradford International College, University of Bradford, ENGLAND.

Email: m.a.e.l.salem@bradford.ac.uk

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INTRODUCTION

Changes in the global landscape of higher education have sparked growing interest in improving the quality of teaching within universities. With the massification, commodification, and diversification of the student body, higher education has emerged as a key driver and indicator of competitiveness in the

global knowledge economy.¹ Like most universities worldwide, Biotechnology and Chemistry faculties at The University of Azad Jammu and Kashmir are typically taught through traditional lecture-based sessions. One such approach is spoon-feeding in education, which can be defined as the process where teachers provide students with all the information, they need to complete a specific task, leaving little room for independent thought or critical thinking on the students' part.² Traditional lectures are effective only to a limited extent in achieving key curriculum objectives, as they do not promote critical thinking. Student attendance tends to be low, and cognitive engagement is often minimal. Additionally, the notion that lectures can and should cover all essential subject matters is misleading. Moreover, there is a lack of empirical evidence on what students learn



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from lectures. A fundamental issue with this approach is that it relies on the information transmission fallacy and the belief that students learn simply by being told.³ Limited and outdated teaching materials and resources are among the most frequently cited barriers to developing effective communication skills in students. These inadequate resources hinder opportunities for practical application, engagement, and the fostering of essential interpersonal skills in educational settings.⁴ Furthermore, the lack of iterative practice, real-time feedback, and the overload of instructional content diminishes students' motivation, self-efficacy, and their ability to fully grasp the essence of effective communication.⁵ To foster student interest, teachers should employ diverse teaching and learning methods, leveraging available technologies in line with evolving trends in the medical field. These learning strategies aim to enhance the educational process, engage students more effectively, and promote deeper analysis and mastery in their domain of study.^{6,7} Students frequently report positive experiences with modified TBL, noting that it offers a highly satisfying and engaging learning environment. Pharmacy students highlight that modified TBL strengthens their professional skills, critical thinking, and communication abilities. Faculty members also view MODIFIED TBL as more effective than other teaching methods in boosting student engagement, preparation, and success in meeting course objectives.⁸ To address the limitations of traditional teaching methods, strategies like Team-Based Learning (modified TBL), Problem-Based Learning (PBL), and flipped classroom approaches have become increasingly popular among educators in various medical science and pharmacy worldwide over the past few years.^{9,10} Team-Based Learning (modified TBL), Problem-Based Learning (PBL), and flipped classroom approaches are innovative teaching strategies that have been established to enhance student engagement by promoting active participation, collaboration, and critical thinking. In many of these teaching and learning strategies, class time is used more efficiently by focusing on discussing and applying fundamental knowledge to solve real-life problems through active learning. This approach encourages the use of higher-order cognitive and critical thinking skills, fostering deeper understanding and engagement among students.^{11,12}

MATERIALS AND METHODS

A total of 71 fourth-year undergraduate students participated in the study, including 36 Biotechnology students and 35 Chemistry students. All participants completed both the pre- and post-intervention assessments. A post-lecture perception survey was completed voluntarily by all participating students.

Study Design

This study employed a quasi-experimental pre-test/post-test educational intervention design to evaluate the impact of a Team-Based Learning modified TBL approach on student academic performance and perceptions.

Study Setting and Participants

The study was conducted during the first semester of the 2023/2024 academic year at the Faculty of Science, University of Azad Jammu and Kashmir, Muzaffarabad.

Fourth-year undergraduate students enrolled in Biotechnology and Chemistry courses participated in the study. Students who attended the scheduled teaching sessions and completed both pre- and post-course assessments were included in the analysis. Students who did not complete both assessments were excluded.

The same student cohorts participated in both pre-intervention (traditional lecture-based teaching) and post-intervention (modified TBL-based teaching) evaluations.

Team-Based Learning Intervention

The teaching strategy implemented in this study represented a modified TBL approach.

One week before each teaching session, students received preparatory learning materials through the course platform, including lecture notes, topic summaries, scientific readings, links to educational resources, and videos. Students were expected to review these materials before class.

During the classroom sessions, students were divided into small teams and participated in collaborative problem-solving activities focused on topic-specific questions and case-based discussions. Teams discussed answers collectively and justified their responses using the preparatory materials.

A scoring system was implemented to encourage participation and engagement. Teams received five points for correct answers on the first attempt and four points after additional discussion if initial responses were incorrect.

Although several core modified TBL principles were incorporated, formal individual Readiness Assurance Tests (iRAT), Team Readiness Assurance Tests (tRAT), and structured peer evaluation components were not fully implemented because of logistical and time limitations.

Assessment Tools

Academic performance was evaluated using pre-course and post-course assessments developed by course instructors and aligned with module learning outcomes. Assessment items focused on knowledge comprehension, application, and problem-solving skills relevant to Biotechnology and Chemistry topics.

Student perceptions regarding the modified TBL experience were evaluated using a structured post-lecture survey adapted from previously published modified TBL educational studies. Survey items explored student engagement, preparation, teamwork, satisfaction, and perceived learning effectiveness.

Applying modified TBL within the Biotechnology and Chemistry Departments at The University of Azad Jammu and Kashmir, Muzaffarabad

This study aimed to evaluate differences in students' satisfaction, understanding, and participation in lectures using Team-Based Learning modified TBL during the first semester. Two different courses in Biotechnology and Chemistry were taught by fourth-year students at the Faculty of Science, the University of Azad Jammu and Kashmir during the 2023/2024 academic year.

Each lecturer within the two faculties introduced the modified TBL method to their students one week before the scheduled lecture. The approach included providing topic-related readings, theoretical content, links, videos, and other preparatory materials on the course's page before the lecture. This enabled students to familiarize themselves with the material and acquire foundational knowledge about the targeted topics in advance. During the lecture, students were divided into teams, and each team was assigned a name. These teams worked together throughout the session.

The questions focused on the specified topic and included a clinical case to evaluate the students' understanding of the material. Students were given time to discuss the case and its answers with their groups. During this period, groups were encouraged to collaborate in problem-solving and to justify their answers through effective interpretation of the pre-class materials provided.

Points were awarded to all students, and the team with the highest score was recognised as the winner to boost enthusiasm and engagement. At the end of the session, an open discussion was held between the lecturer and the students to address the questions. Each team received a full 5 points for each correct answer on the first attempt. If a team's answer was incorrect, they had the opportunity to discuss alternative answers, receiving 4 points for each correct answer after further discussion.

Statistical Analysis

Data were analysed using GraphPad Prism version 9.0 for Windows (GraphPad Software, USA). Results are presented as mean $\pm$ Standard Deviation (SD).

Normality assumptions were assessed before analysis. Pre- and post-course assessment scores were compared using paired *t*-tests. A *p*-value of less than 0.05 was considered statistically significant.

RESULTS

Academic Performance Outcomes

The implementation of the Team-Based Learning approach was associated with significant improvements in student academic performance in both Biotechnology and Chemistry groups compared with traditional lecture-based instruction.

Biotechnology Group

Post-course assessment scores in the Biotechnology group were significantly higher following implementation of the modified TBL approach compared with pre-course lecture-based assessment scores ($p < 0.05$) (Figure 1).

The results suggest that collaborative learning activities and application-focused discussions enhanced student understanding and retention of course material.

Chemistry Group

Similarly, Chemistry students demonstrated significant improvement in post-course assessment scores following implementation of the modified TBL approach compared with lecture-based teaching ($p < 0.05$) (Figure 2). The interactive nature of team discussions and problem-solving activities appeared to support deeper engagement with course content. Overall, both student groups demonstrated improved academic performance following implementation of the modified TBL intervention.

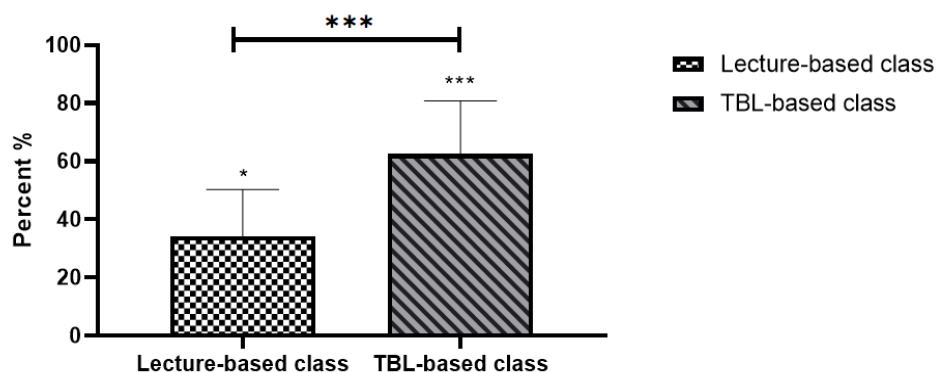


Figure 1: Comparison of pre-course (lecture-based) and post-course (modified TBL-based) assessment scores in Biotechnology students, $n=36$ students. Data are presented as mean $\pm$ SD. Statistical analysis was performed using paired *t*-test (* $p < 0.05$).

Overall, both groups exhibited a significant increase in test scores from pre- to post-course assessments, highlighting the effectiveness of modified TBL in improving academic performance when compared to traditional lecture-based instruction. The results suggest that modified TBL not only improved test scores but also promoted active learning and engagement across different disciplines.

Student Perception Survey

Student responses to the post-lecture survey indicated generally positive perceptions regarding the modified TBL experience.

Most students agreed that the modified TBL sessions

promoted active participation, improved collaboration and teamwork, enhanced engagement with course content, and encouraged deeper learning and preparation.

Students also reported that team discussions improved their understanding of difficult concepts and facilitated knowledge sharing among peers.

However, some students reported challenges related to time management and preparation before class sessions. All percentage values reported in Table 1 were recalculated and verified to ensure consistency and transparency.

The post-lecture survey results in Table 1 and Figure 3 suggest that Biotechnology and Chemistry students had a positive experience with modified TBL, particularly in terms of engagement, comprehension, and the ability to apply knowledge. While the method required more active participation and preparation, most students found that the benefits outweighed the challenges.

DISCUSSION

In this study, we implemented the first applied Team-Based Learning modified TBL model at the Faculty of Sciences at the University of Azad Jammu and Kashmir. The aim was to evaluate whether the modified TBL approach could enhance reasoning, improve knowledge retention, and increase student enjoyment in Biotechnology and Chemistry courses.

This study found that modified TBL can be an effective instructional approach that could improve biotechnology students' performance on examinations when compared to biotechnology students who received traditional didactic lectures. This result agrees with a few studies that have shown that modified TBL had a positive effect on student examination performance. Similarly, modified TBL was more effective than small-group teaching in the achievement of knowledge objectives of three clinical topics in a clinical clerkship.¹³

The primary aim of this study was to gain a deeper understanding of students' perceptions of the modified TBL experience, given the limited pre-existing data on their experiences with this teaching method. By exploring students' opinions, beliefs, and disparities, this study seeks to connect research findings on modified TBL with its practical application. Students reported that team discussions helped uncover various learning gaps, and they found it easier to understand the material when explained by a peer, rather than by a teacher. This aligns with other studies that have demonstrated how peer-assisted learning within the context of modified TBL can enhance both students' enjoyment and overall learning experience.^{13,14} In this setting, the peer teacher better understands and relates to the difficulties that fellow students face, allowing them to explain complex concepts in a way that peers can more easily perception.¹⁵

Some challenges observed during group discussions included a small number of students not participating, often due to inadequate preparation before class. Additionally, students reported that studying the material independently was a significant difficulty, primarily due to limited time.

To address these challenges, students were organised into teams with diverse skill sets, backgrounds, and perspectives. This approach promotes varied viewpoints and encourages all members to contribute actively, ensuring that each student understands their role in the discussion and is motivated to participate. Additionally, assessments were designed to require critical thinking and problem-solving, rather than mere rote memorisation. By implementing these strategies, student engagement and effectiveness during discussions in a modified

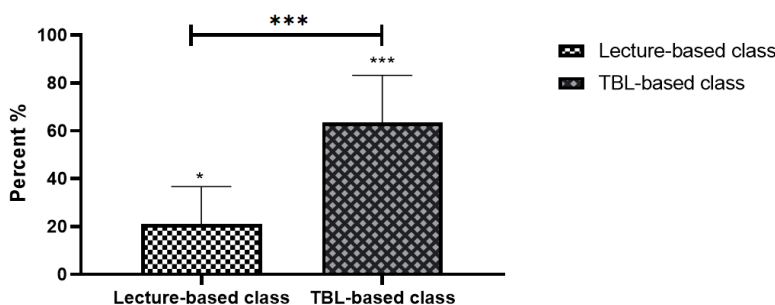


Figure 2: Comparison of pre-course (lecture-based) and post-course (modified TBL-based) assessment scores in Chemistry students, $n=35$ students. Data are presented as mean $\pm$ SD. Statistical analysis was performed using paired t-test ($*p<0.05$).

Table 1: Student perceptions regarding the Team-Based Learning experience among Biotechnology and Chemistry students, n=71 students.

	% Strongly disagree/ disagree	% Strongly agree/ agree	% Neutral
I feel that I need to prepare thoroughly for this class to perform well	27	46	10
I actively contribute to the team's learning process	12	34	5
My team relies on me to support their learning	10	47	4
I retain information better when working in teams	16	48	7
I can easily remember the material from the lecture	42	26	9
I enjoy participating in MODIFIED TBL activities	31	43	4
I learn more effectively in a team setting	14	50	7
I believe MODIFIED TBL activities are an effective learning approach	29	38	7
MODIFIED TBL helped you be prepared for your final exam	42	36	3
MODIFIED TBL helped you study more deeply	29	32	5
Would use this method in other courses	50	48	3
I think MODIFIED TBL activities contribute to improved grades	18	6	7
Recommend MODIFIED TBL to other students	26	37	4
MODIFIED TBL changed the way you now study	20	27	8

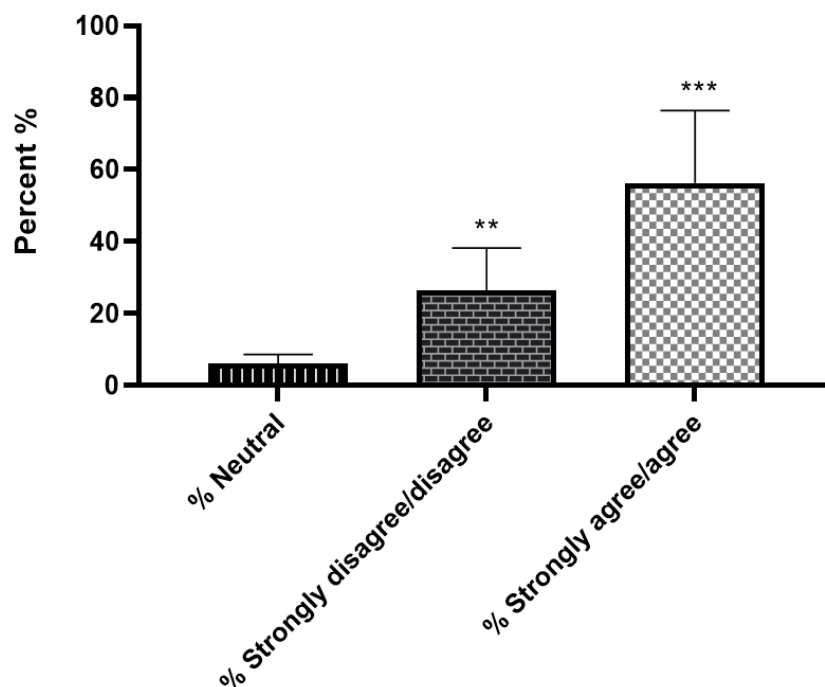


Figure 3: Post-Lecture Survey: Biotechnology and Chemistry students' Perspectives on the Team-Based Learning Experience presents feedback from Biotechnology and Chemistry students regarding their experience with Team-Based Learning (modified TBL). n=71 students. Data are presented as mean $\pm$ SD. Statistical analysis was performed using paired t-test (* $p < 0.05$).

TBL approach were enhanced, leading to a more productive and interactive learning experience.

Overall, students' average performance was higher in the modified TBL class compared to the traditional class (Figure 1). Additionally, there was a noticeable improvement in biotechnology reasoning skills over time, as students demonstrated enhanced ability to provide comprehensive explanations of differential diagnoses and therapeutic choices, utilising various technologies in the field.

A unique challenge encountered by students in this study was related to the exam structure at Lahore University. Each module generally includes three major assessments: the First, Second, and Final Exams. The First and Second Exams are held in weeks 5 and 9 of the semester, each contributing 20% to the final module grade. As a result, student attendance dropped during these exam periods because many students, unprepared for the material, opted not to attend class. This reduced attendance adversely affected overall team performance due to fewer participating members.

CONCLUSION

In conclusion, a modified TBL classroom has been established in our faculty to support this teaching method. Peer evaluation, a crucial component of modified TBL, allows students to receive feedback from their peers on various aspects of their performance, including attendance, preparation, participation, and collaborative skills, through an evaluation form. However, due to time constraints, peer evaluation was not implemented during this modified TBL experience. To enhance teamwork and the development of collaborative skills, future iterations of the module should incorporate peer evaluation. Looking ahead, modified TBL could serve as an effective alternative teaching modality in the Faculty of Sciences, addressing some limitations of traditional didactic lectures and improving student engagement. modified TBL would be especially advantageous in settings facing challenges such as a high faculty-to-student ratio, the need for multiple teaching spaces, and the short duration of certain courses, where other group-teaching methods may be less practical.

Modified TBL can enhance Biotechnology and Chemistry students' engagement and critical thinking skills. Therefore, it should be incorporated into the curriculum at the University of Azad Jammu and Kashmir to foster the development and application of life sciences skills. However, the curriculum should be adapted to accommodate this learning process. The present study provides preliminary evidence supporting further investigation and gradual implementation of modified TBL approaches within science education curricula. Future research involving validated assessment tools and long-term evaluation is recommended.

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ABBREVIATIONS

TBL: Team-Based Learning; **PBL:** Problem-based learning; **iRAT:** Individual Readiness Assurance Test; **tRAT:** Team Readiness Assurance Test; **SD:** Standard Deviation; **PBL:** Problem-Based Learning.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

SUMMARY

The present study explored the application of Team-Based Learning modified TBL in Biotechnology and Chemistry modules at the University of Azad Jammu and Kashmir. modified TBL was applied as an alternative to traditional lecture-based instruction. The traditional lecture was associated with a limitation in student engagement and unsatisfactory development of critical thinking skills for students. The implementation of modified TBL enhanced student participation, comprehension, and collaboration.

Fourth-year students took part in structured modified TBL sessions, including pre-class preparation, team discussions, and application-focused assessments. Comparative analysis was carried out by utilising the Statistical analysis of pre- and post-course test scores. This statistical analysis demonstrated a statistically significant enhancement in academic performance across both disciplines.

Moreover, post-lecture surveys revealed the improvement of student satisfaction, deeper conceptual understanding, and improved critical thinking capabilities.

Despite challenges, low levels of attendance during examination periods and variable levels of student preparation, the outcomes help the pedagogical benefit of modified TBL. This study concluded that modified TBL promotes an interactive, student-centred learning environment and proposed the implementation of modified TBL across medical and health science curricula to enhance students' academic progression, learning outcomes and transferable skills.

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