Dynamics of Team Based Learning in Molecular Biology: Insights and Reflections from Undergraduate Medical Students

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Article

Dynamics of Team Based Learning in Molecular Biology: Insights and Reflections from Undergraduate Medical Students

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Abstract: The objective of the study was to investigate the dynamics of collaborative learning in TBL through students' reflections and feedback. The study utilized a mixed-methods approach. Quantitative data collection was done via feedback structured questionnaire. Qualitative data were collected from reflections submitted by 107 first-year MBBS students at the end of TBL session. We found five main themes related to students' engagement with the session i.e. (1) conceptual clarity as the foundation, (2) collaborative learning culture, (3) communication skills, (4) informative and useful team discussions and (5) interactive learning for team development. The majority of the respondents (93%) listened to classmates and coordinated with group members in discussion, (77%) were willing to learn from other group members and contributed ideas to them, (79%) came prepared for session, (75%) found learning material assigned to them as appropriate. Respondents had positive perceptions regarding their participation in group work with a strong inclination towards agreement with the statements provided. The study highlights the positive effects of TBL in promoting peer to peer engagement, active engagement, teamwork skills, and knowledge sharing among undergraduate medical students, ultimately contributing to an effective learning experience.

Keywords: team work; collaborative learning; Conceptualization; communication skills; medical school

Introduction

Team-Based Learning (TBL) is a collaborative learning approach that has gained popularity in recent years due to its effectiveness in promoting active learning, critical thinking, and problem-solving skills [1,2]. It is a structured learning method that involves students working in small groups requiring pre-class preparation by students and in-class application of knowledge to solve complex problems, discuss case studies, and apply their knowledge to real-world scenarios. It originated as a teaching method in business schools in the early 1990s and was developed by Dr. Michaelson [3,4]. It is an effective teaching method across a range of disciplines, including medicine, nursing, engineering, and business [5,6]. It has been associated with increased student motivation, satisfaction, and knowledge retention, highlighting its positive impact on the overall learning experience [7–9]. TBL provides opportunities to use and enhance conceptual knowledge through a variety of processes, such as preparation, readiness assurance testing, feedback, and the application of knowledge through clinical problem -solving activities [10,11]. The TBL's simplified framework tackles resource constraints that are frequently faced by universities. Enabling a large number of students to participate in small group learning with a limited number of knowledgeable facilitators is another important benefit of TBL [12,13]. There is a scarcity of literature on conduction of team-based learning

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in developing countries, as the majority of studies tend to concentrate on its application in more developed regions [14]. Therefore, this study explored the dynamics of collaborative learning in TBL and examined the perception of TBL by undergraduate medical students in Pakistan. The study aims to contribute to the growing body of research on TBL and to provide insights into the dynamics of collaborative learning in medical education. The objective of the study was to investigate the dynamics of collaborative learning in TBL through students' feedback and reflections.

Study Methods

This study adopted a phenomenological mixed-methods approach where survey and reflections were conducted concurrently after TBL session and results were analyzed.

Setting and Participants:

Study employed single- stage cluster technique to include all first year MBBS students of batch 2023-24 with age range between 19 to 22 years. Students who were absent on the day of session or did not consent to participate were excluded from the study. The data wee collected from 107 first year MBBS students in April 2024, at private medical college in Lahore, Pakistan. Duration of study was from April 2024 to July 2024.

Recruitment:

Students were invited to participate in the study by distributing consent forms of the study at the beginning of the study. Those who were willing to participate were given feedback questionnaire and were asked to write reflections about it. Students were provided with information about the purpose, of study to facilitate informed decision about participation. It was emphasized that participation was entirely voluntary and that students had all the right to withdraw at any stage of the study and will not be penalized. Personally, identifiable information, such as names, were not collected. Confidentiality and anonymity were assured. The study was presented In Ethical Review board and was granted exempted review vide letter IRB No 0744 Ref no: SMDC-IRB/AL/2024-041.

Conduction of TBL Session:

TBL session was conducted for two hours with all the steps of the session being followed as described below:

1. ***Preparation Phase*:**

Students were provided with learning objectives of the session along with clinical cases related to molecular biology through Learning Moodle System (LMS) to study individually before the TBL session (Table 1). They were instructed to revise the topics covered in previous lectures to prepare for the TBL session.

Table 1. Clinical Cases of Molecular Biology. The table shows clinical cases given to students prior to the TBL session for individual study.

Case 1	A diabetic woman, aged 23, exhibits symptoms of dysuria, chills, and a high grade fever. Urinary analysis demonstrates the presence of germs in the urine, and physical examination reveals Costo-vertebral pain. Her doctor starts her on a 5-day treatment of ciprofloxacin since she may have a complex UTI. What is the mechanism of action of Ciprofloxacin? How it prevents the proliferation of infection.
Case 2	An annual physical checkup is performed on a 34-year-old guy of Italian origin. He is in terrific health and has no problems. Nevertheless, a full blood count indicates a mild anemia, and he has a family history of anemia. The doctor believes the patient has thalassemia minor. Since RNA splicing is a crucial component of mRNA processing in eukaryotes, thalassemia is frequently caused by changes in this process.

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	What is the mechanism of RNA splicing? In which process it takes place? What alteration can take place in RNA splicing that can lead to Thalessemia?
Case 3	A 54-year-old guy comes in to see his family doctor after suffering from a low-grade fever and ineffective cough for three to four weeks. The doctor chooses to use erythromycin as an empirical treatment for the patient because they appear to have an unusual pneumonia caused by Mycoplasma pneumoniae. What is mechanism of action of erythromycin and how it prevents the growth of bacteria?
Case 4	A new patient arrives at a medical outpatient clinic fearing he has colon cancer. Numerous members of my family experienced right-sided colon cancer, with visible polyps only present on the afflicted side; all cases happened before the age of 45. Explain the reason for this type of cancer in families
Case 5	A patient with cramps, vomiting and chills was sent to the emergency department. His nourishment came from the wild mushrooms he had picked earlier in the day. Why the patient has symptoms on eating mushrooms? What is its mechanism for developing these symptoms?
Case 6	A two-year-old girl complains of having a tight neck and has a sudden, high grade fever. Petechiae on the extremities and a positive Brudzinski and Kernig sign are found during the physical examination. In addition to sending the child immediately to the hospital, the pediatrician also recommends a medication that prevents the formation of prokaryotic peptide bonds, despite the possibility of serious side effects. Which is the drug and how it acts?
Case 7	A 2-year-old boy with an ear infection was given amoxicillin, but it did not clear up the problem. Switching to azithromycin successfully eradicated the infection, and subsequent laboratory work indicated that the offending bacterium was resistant to amoxicillin. What is the mechanism that leads to Bacterial resistance in patients?

2. *Readiness Assurance Process (RAP)*:

Individual Readiness Assurance Test (iRAT):

Students were given pre -test at the start of session which comprised of 10 multiple-choice questions (MCQs) related to the pre-assigned material to assess their individual readiness for the session.

Formation of Groups: Following the RAP, the class was divided into four groups (e.g., Groups A, B, C, D) for the TBL session and group representatives were identified in each group. These groups were further subdivided into small groups of 5-6 students in each group and engaged in discussion of case studies provided to them for preparation.

They worked in their teams to analyze the problem, discuss potential solutions, and apply their knowledge to solve it. Facilitator was there to encourage active participation and discussion amongst students.

3. ***Team Readiness Assurance Test (tRAT):*** Post-test was conducted to assess the readiness of participants after collaborative study in groups and comprised of 10 to 15 MCQs.

Pre- and Post-tests: Objective assessments were conducted to measure any changes in academic performance after individual study (pre-test) and after collaborative study in groups (post -test).

4. Reporting and Discussion:

Each team presented their solutions or findings to the class. This stage encourages peer teaching and allows for comparison and discussion of different approaches. Instructors also provided additional insights, clarified concepts, or addressed misconceptions during this phase. Group representatives presented their findings and explanations to the class, fostering peer-to-peer learning and knowledge sharing. The session focused on topics such as DNA replication, transcription, and translation in biochemistry.

5. Assessment and Evaluation:

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Students were evaluated based on their participation, understanding of the cases, and the accuracy of their explanations. Marks were awarded to teams (A, B, C, D) based on the quality of their responses and contributions during the TBL session. Following Case scenarios were given to the students.

6. Feedback: Feedback was taken from the students on questionnaire and were asked to write reflections in 15 minutes

Quantitative Data Collection

Data was extracted from a structured feedback questionnaire distributed to students of first year MBBS regarding perceptions of TBL, based on a three-level Likert scale after TBL session (Table 2).

Table 2. Perceptions of Undergraduate Medical Students Regarding TBL.

	Questions	**Strongly Agree**	**Somewhat Agree**	**Disagree**
1.	I contributed ideas to the group			
2.	I listened to my class-fellows			
3.	I was flexible and willing to learn from other group members			
4.	I came to group discussion prepared for work			
5.	I found appropriate materials for group work			
6.	I coordinated with my group members			
7.	I took initiative when needed without being boss			
8.	I completed my tasks without taking over complete work			
9.	I supported other group members when they needed help			
10.	My contribution to the group work reflects my best effort			

Qualitative Data Collection

Students were encouraged to write their reflections and responses based on their TBL experience and collaborative group discussions to delineate their level of satisfaction. Qualitative data was collected from their reflective writings which were open ended and themes identified using NVIVO by creating codes and sub-codes.

Data Analysis

Quantitative data was analyzed using SPSS ver. 23. Frequency and percentage was determined for items on Likert's scale. Qualitative data was analyzed using NVIVO. to identify themes, coding themes and subthemes. Thematic analysis was done for qualitative data using phenomenological framework. Each reflection was read by members of the team and impressions discussed. Codes and sub codes were identified and coding disagreements were resolved by consensus. Study team discussed the coded data to identify themes related to the objectives of the study.

Data Integration

Analysis of qualitative and quantitative data was initially done separately. The major themes were then considered alongside the survey findings. Qualitative and quantitative data was aligned by analyzing themes identified along with the findings of questionnaire. The study members analyzed the areas of convergence and divergence and comprehend the findings in questionnaire to detailed discussions in reflections.

Results

A total of 107 participants were surveyed using a structured questionnaire, with Likert scale where 1 denoted 'Disagree', 2 denoted 'Somewhat Agree' and 3 denoted 'Strongly Agree'.

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Participants were asked to choose a response that best represented their opinion on the given statements. The responses of the participants were plotted on a Clustered Column chart (Figure 1).

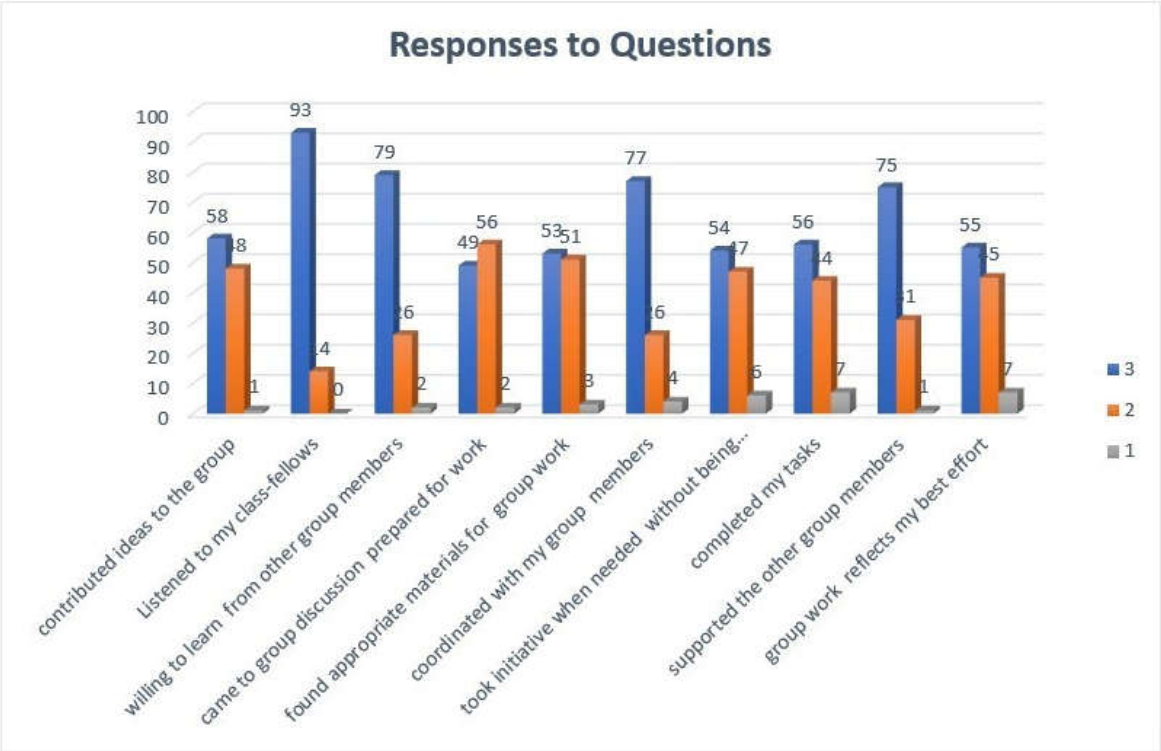

Figure 1: Quantitative analysis of Feedback by students to Questions regarding TBL based on Likert's scale

The majority of the respondents (93%) strongly agreed that they listened to classmates and coordinated with group members in discussion. Others (77%) strongly agreed that were willing to learn from other group members and contributed ideas to the group (79%), They came prepared for session (75%), found learning material assigned to them as appropriate for group work (58%), and took initiative to participate when needed (53%). They completed the tasks in time (54%), supported other group members (56%) and felt that their group work reflected their best effort (55%). Rest somewhat agreed and only 3% respondents disagreed with the statements (Figure 1).

Themes and Subthemes

Themes and subthemes were identified as shown in Figure 2. Group, discussion, session, cases, team, TBL, learning, concepts, questions were most frequently coded words. Themes identified were conceptual clarity as foundation, collaborative learning culture, communication Skills, very Informative and useful team discussions and interactive learning for team development.

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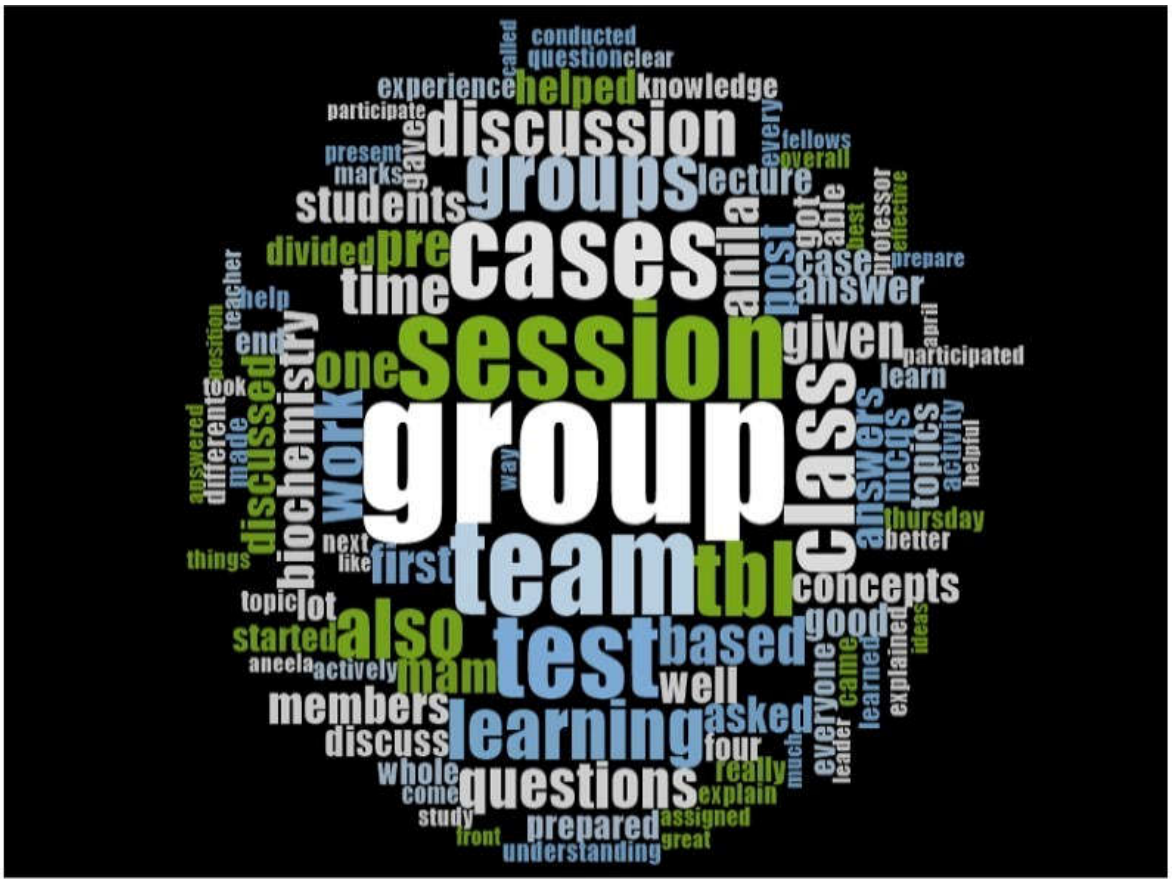

Figure 2: Word Cloud shows themes and subthemes identified through students' reflections

The occurrences were counted and plotted on a 'Clustered Bar Chart' to gain a deeper understanding of the data (Figure 3).

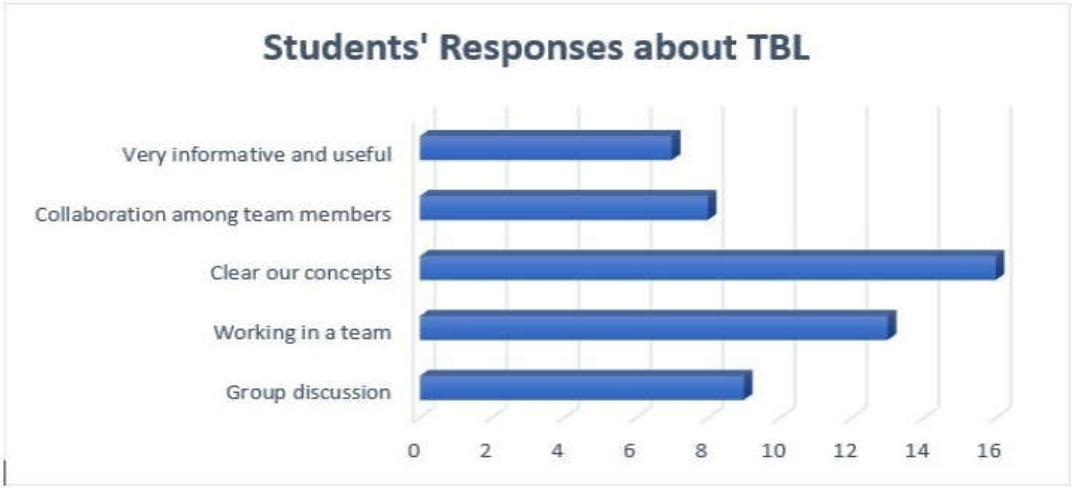

Figure 3: Themes identified From Reflections

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Conceptual Clarity as Foundation:

Students express gratitude for the session, emphasizing its helpfulness in clearing concepts and aiding memorization. It helps them to grasp the concepts clearly, increased interest in the TBL session itself, as evident from the quotations of participants shown in Table 3. The strategy of dividing students into groups for questioning added an interactive dimension, promoting collaborative learning.

Collaborative Learning Culture:

Collaborative learning is crucial for effective teamwork, promoting a culture of mutual learning. Students actively assist peers in understanding challenging concepts, demonstrating the productivity of discussing problems and acquiring new knowledge during sessions. Hindrances in collaboration was lack of confidence and ill- preparation as mentioned by the participants (Table 3).

Table 3. Participant's quotations against the Themes Identified. The table shows the quotations of students for different themes identified from their reflections. It shows their personal views about the Team based Learning (TBL).

Themes	Quotations
Conceptual clarity as the foundation	*"I thought this session was helpful because it helped us clear our concepts and memorize most of the topics".* **(Participant 6)** *"Helping others also deepens your own understanding of the concepts".* **(Participant 65)**. *"I am happy with myself for helping my group mate out with revising the process of gene splicing. It felt nice to help them out and it solidified my own concept as well".* **(Participant 21)** *"Our concepts got more cleared due to TBL and we learned to cooperate with other fellows. After discussion Professor took a post assessment test and I personally felt that I can give answers more clearly now. I will anxiously wait for next TBL session".* **(Participant 31)** *"We cleared our concepts regarding every topic. There was a great discipline in the class. It was a new experience for me but was a great one".* **(Participant 19)** *"I really enjoyed this way of learning since it consolidated all my concepts with the constant repetition. However when the professor asked me a question I got anxious and forgot the answer even though I knew it, that really set me off".* **(Participant 50)** *"In this lecture the teacher divided us into groups and started asking questions group wise. In my opinion it is very effective method as we get to understand the concepts from different people in different ways. Such activities help us to study in lighter environment."* **(Participant 30)** *"I was ecstatic to hear that our Group C had secured the first position. At the end we had a post discussion test that we quickly solved, but this time all my answers were correct and it took me less time to answer them since I was having no confusion".* **(Participant 34)**
Collaborative Learning Culture	*"My greatest strength during group work:* *I helped my peers in understanding tricky concepts and tried to answer the questions asked by the facilitator".* **(Participant 103)** *"Discussing the problems with my fellows and sharing my thoughts on it was productive...such sessions should be conducted back to back in our class."* **(Participant 69)** *"With the help of teamwork I will be able to become a good doctor capable of listening to others' advice and help others".* **(Participant 9)**

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	"All the groups had a wonderful collaboration in them. I, along with other members, also contributed ideas to the group. I listened to other class fellows and learned from their ideas". **(Participant 10)** *"I found that my weakness is lack of confidence to answer the question in front of everyone. I'll try my best to overcome my weaknesses".* **(Participant 2)** *"My preparation was below par compared to my teammates, thus I was not able to contribute to the maximum of my ability".* **(Participant 13)** *"We were upset because we couldn't get the first but we appreciated all of our members because we really had a great time in this session".* **(Participant 5)**
Communication Skills as the Glue	*"Teacher asked me to elaborate the case 1. I explained the case and got cheers from my group and teachers. At the end of the lecture, teacher announced the results and my group won the TBL test".* **(Participant 37)** *"Team work was the best initiative taken by Shalamar Medical and Dental College as it helped us learning new things and developed a sense of good communication skills with our members".* **(Participant 12)** *"The best thing about this lecture was that I was the team leader and was able to participate and present ideas".* **(Participant 46)** *"During the class discussion…the concepts were explained in such a way that I was able to absorb the new information easily".* **(Participant 48)** *"Where there are strengths, there are weaknesses. My greatest weakness was that of miscommunication. This is highly attributed to my fast speech. I speak very fast and this leads to some words being unclear. My teammates were having a bit difficulty keeping up with the pace, so I had to repeat my statements once or twice".* **(Participant 22)** *"I tried to be the best version of myself. My only weakness is lack of confidence and I am trying to cope with this difficulty. Inshallah I will overcome this weakness".* **(Participant 32)**
Informative and useful Team Discussions	*"In my opinion, this session was very informative. Ma'm helped a lot to understand difficult things .The other staff members were also cooperative. At the end I have to say that these type of sessions are so useful".* **(Participant 8)** *"Overall, it was an amazing experience which helped us a lot in learning and understanding".* **(Participant 17)** *"It's important to establish clear goals and roles, communicate effectively, and respect each other's contributions. When done right, teamwork can lead to increased productivity, creativity, and satisfaction for everyone involved".* **(Participant 43)** *"Each and every student was eager to learn something new and which happened also, overall it was a good practice".* **(Participant 28)** *"It was really good and very fun and interesting. My God really have too much mercy on me. Everything in which I present gets victory".* **(Participant 33)** *"The session was very interactive. It was very informative too. The whole session was basically about learning to interact to increase your knowledge and understanding".* **(Participant 76)** *"I need to be more creative next time in order to contribute better ideas. This team work enabled me to ponder over my weaknesses. Now I will surely work on my deficiencies and will become a better team member".* **(Participant 42)** *"Before taking the TBL session I thought that it will be really a hectic lecture. But when lecture started I was wrong...Because Professor made it so easy that it was really informative as well as really good".* **(Participant 45)**
Interactive Learning for Team Development	*"Overall, the team-based learning session was a positive experience. It allowed me to work with my peers, gain new insights into the topic, and feel a sense of accomplishment as a team".* **(Participant 102)**

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	"Working in a team has been something I have liked doing since my A' levels. Learning in small groups helps you memorize stuff better, that is what I took away from this TBL session". **(Participant 15)**
	"The Team Based Learning session was an interactive learning session…I personally benefited from this session because the ambiguities I had regarding a few topics were cleared by the end of this session". **(Participant 20)**
	"You can work as a team to move a couch up a flight of stairs, launch a work project, or play soccer. Defining teamwork is simple, but understanding how to work well as a team can be complicated". **(Participant 16)**
	"We also learned to work as a team. This will help us in our professional lives, as a doctor alone, cannot make great things to happen". **(Participant 87)**
	"Working in a team can also help to improve your communication and develop a sense of camaraderie…overall team work can be incredibly rewarding experience". **(Participant 3)**
	"Usually when you learn 5 to 6 topics individually, it takes a lot of time but when you're doing it together, you can save a lot of time. So, this way this session helped us a lot". **(Participant 36)**
	"I contributed by telling my team members what to say, however, I was too shy to actually go to the front and present". **(Participant 1)**

Communication Skills as the Glue:

Effective communication is crucial for team collaboration and successful outcomes, as it binds team members together and converts conceptual clarity into actionable plans. Participants candidly recognized their weaknesses in communication as elaborated in Table 2.

Informative and Useful Team Discussions:

TBL session acted as a valuable opportunity to interact with peers, increased knowledge, and deepened understanding of the subject matter. Learning new things was the core idea of this session. Teamwork also enabled the students to observe their weaknesses as evident by their perceptions shown in Table 3.

Interactive Learning for Team Development:

Interactive learning sessions were portrayed as dynamic environments where learning becomes a shared experience, contributing to a sense of collective purpose and shared goals. Participants highlighted the opportunity to collaborate with peers, which not only facilitates a deeper understanding of the topic but also fosters a sense of achievement as a team. The Interactive learning experience within a team-based environment, not only enhances understanding of course material but also cultivates essential teamwork skills that are invaluable for future professional endeavors. Together, this painted a comprehensive picture of the multifaceted nature of effective teamwork, providing a roadmap for Team based Learning seeking to optimize the collaborative potential.

The appreciation of students to understand the concept via interactive sessions and the reluctance to participate are depicted in Table 3.

Discussion

This study provides valuable insights into the effectiveness of collaborative learning approaches among undergraduate medical students. The findings indicated a generally positive response from the participants, with a majority strongly agreeing with statements related to contributing ideas, listening to classmates, being prepared for work, and supporting group members. This suggests a high level of engagement and cooperation within the TBL sessions, highlighting the benefits of collaborative learning in enhancing teamwork skills and knowledge sharing [15,16].

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Themes identified in our study were conceptual clarity, collaborative learning culture, communication skills, informative team discussions, and interactive learning for team development. These themes underscore the importance of effective communication, knowledge sharing, and interactive learning experiences in fostering team unity and enhancing individual skill. Another exploratory study was conducted on teaching and learning strategies at tertiary care hospital in Pakistan [17]. Mansoor et al., [18] conducted study on comparative evaluation of academic performance in second year MBBS students between those taught by TBL versus SGD (small group discussion), however both were found to be equally effective. Another study showed that implementation of TBL increased students' responsibility for their own learning and helped the students in bridging the gap in their cognitive knowledge which results in increased scores in summative assessment of students who undertook TBL sessions [19]. Study by Woodcock et al., [20] concluded that TBL stimulates critical thinking amongst the students and make them realize how clinicians think and apply basic sciences content in the clinical set up. Another study revealed that critical thinking dimensions such as inquisitiveness, analyticity are statistically significant [21]. TBL enhances students' problem-solving skills by allowing them to gather relevant material, debate, ask questions, and receive feedback. It also boosts confidence, enhances study habits, and promotes responsibility in education [22]. Interactive learning sessions, facilitated by clear goals, effective communication, and mutual respect, are appreciated for their informative nature, team development, improved memorization, and time-saving benefits [23,24]. Students take a proactive approach to problem-solving by actively participating in class discussions. This process of mutual learning emphasizes how new information can be learned from peers. When working in groups, students actively help classmates grasp difficult subjects, showcasing their strongest skills, as shown by these studies [25,26].

Good communication skills are essential for good teamwork. They convert abstract ideas into workable plan. The study shows that the team-based learning facilitates the improvement of communication skills among participants. These help participants become more successful and have a deeper grasp of the difficult topics [27].

Interactive training sessions are an effective way to build a team by strengthening individual members and promoting togetherness. These group activities foster dynamic settings where education becomes a shared experience, strengthening the sense of purpose and objectives among participants. Working together with peers promotes team success and greater understanding. Effective interactive sessions are an important tool for learning and teamwork since they help with memorization and clarify ambiguity about particular topics [8,27].

Teamwork enhances course comprehension, develops collaboration skills, fosters rapport, and is fulfilling. Theme analysis highlights connections, communication, debates, and interactive learning for maximum potential.

Conclusion:

The combined findings from both quantitative and qualitative analyses provide a nuanced understanding of collaborative learning in TBL. By contributing to the enhancement of TBL practices in medical education, this research offers valuable implications for educators looking to incorporate this learning approaches into their teaching strategies. Overall, the study highlights the positive effects of TBL in promoting peer to peer engagement, active engagement, teamwork skills, and knowledge sharing among undergraduate medical students, ultimately contributing to a more enriching and effective learning experience.

This study promotes the use of Team-Based Learning (TBL) in developing countries, highlighting the need for resources, training, and hands-on workshops for faculty members to design and facilitate TBL activities effectively. It aims to optimize student engagement and learning outcomes.

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Limitations of the Study:

The study also has some limitations such as potential selection bias from a single institution, limited generalizability due to geographical variation, self-reporting bias in data collection, lack of longitudinal data for long-term assessment and methodological challenges in data analysis. Feedback from faculty was not considered.

Author's Contributions: • Conceptualization: AJ. • Data curation: UA. • Formal analysis: SJ GF. • Funding acquisition: Not Applicable. • Methodology: GF SJ RMHS. • Project administration: AJ. • Visualization: RMHS. • Writing – original draft: UA GF. • Writing – review & editing: AJ,MZB.

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Conflict of Interest: No.

References

1. Michaelsen LK, Knight AB, Fink LD, editors. Team-based learning: A transformative use of small groups in college teaching. New York; Taylor & Francis; 2023.
2. Yeung MM, Yuen JW, Chen JM, Lam KK. The efficacy of team-based learning in developing the generic capability of problem-solving ability and critical thinking skills in nursing education: A systematic review. Nurse Education Today. 2023;122:105704.
3. Ali SS. Problem based learning: A student-centered approach. English language teaching. 2019;12(5):73-8.
4. Bergmann M, Schäpke N, Marg O, Stelzer F, Lang DJ, Bossert M, Gantert M, Häußler E, Marquardt E, Piontek FM, Potthast T. Transdisciplinary sustainability research in real-world labs: success factors and methods for change. Sustainability Science. 2021;16:541-64.
5. Parappilly M, Woodman RJ, Randhawa S. Feasibility and effectiveness of different models of team-based learning approaches in STEMM-based disciplines. Research in Science Education. 2021 ;51:391-405.
6. Sannathimmappa MB, Nambiar V, Aravindakshan R, Kumar A. Are Online Synchronous Team-Based-Learning (TBL) pedagogy effective? Perspectives from a study on medical students in Oman. Journal of Advances in Medical Education & Professionalism. 2022;10(1):12.
7. Odongo CO, Talbert-Slagle K. Training the next generation of Africa's doctors: why medical schools should embrace the team-based learning pedagogy. BMC medical education. 2019 ;19(1):1-8.
8. Burgess A, van Diggele C, Matar E. Interprofessional team-based learning: building social capital. Journal of Medical Education and Curricular Development. 2020 ;7:2382120520941820.
9. Trullàs JC, Blay C, Sarri E, Pujol R. Effectiveness of problem-based learning methodology in undergraduate medical education: a scoping review. BMC medical education. 2022 ;22(1):104.
10. Burgess A, Matar E, Roberts C, Haq I, Wynter L, Singer J, Kalman E, Bleasel J. Scaffolding medical student knowledge and skills: team-based learning (TBL) and case-based learning (CBL). BMC Medical Education. 2021;21(1):238.
11. Burgess A, Roberts C, Ayton T, Mellis C. Implementation of modified team-based learning within a problem based learning medical curriculum: a focus group study. BMC Medical Education. 2018 ;18(1):1-7.
12. Roossien L, Boerboom TB, Spaai GW, de Vos R. Team-based learning (TBL): Each phase matters! An empirical study to explore the importance of each phase of TBL. Medical Teacher. 2022;44(10):1125-32.
13. Burgess A, van Diggele C, Roberts C, Mellis C. Team-based learning: design, facilitation and participation. BMC Medical education. 2020 ;20(2):1-7.
14. Nelson M, Tweddell S. Outcomes of implementing Team-Based Learning (TBL): the experiences of UK educators. [Internet]. 2020 ;3(1):198-212.
15. Christensen J, Harrison JL, Hollindale J, Wood K. Implementing team-based learning (TBL) in accounting courses. Accounting Education. 2019;28(2):195-219.
16. Cevik AA, ElZubeir M, Abu-Zidan FM, Shaban S. Team-based learning improves knowledge and retention in an emergency medicine clerkship. Int J Emerg Med. 2019;12(1):1-8.
17. Khan A, Khan SA, Turi SH. An exploratory study focusing on teaching and learning practices at the tertiary level in Pakistan: A case study of a public sector university. Int J Educ Dev. 2017;54:39-48.
18. Mansoor M, Aly SM, Javaid A. Effect of Team-based Learning on Second Year Students' Academic Performance. J Coll Physicians Surg Pak. 2019;29(9):860-864.
19. Anwar K, Shaikh AA, Sajid MR, Cahusac P, Alarifi NA, Al Shedoukhy A. Tackling student neurophobia in neurosciences block with team-based learning. Med Educ Online. 2015;20:28461.

 doi:10.20944/preprints202407.2537.v1

20. Woodcock J, Henderson C, Sheakley M. To What Extent Do Faculty and Students Believe that Team-Based Learning Supports Important Goals of Undergraduate Medical Education? Med Sci Educ. 2022 ;32(5):1107-1116.
21. Zeb MA, Mahboob U, Shaheen N. Effect of team-based learning on critical thinking: A quasi-experimental study. Pak J Med Sci. 2022 ;38(8):2234-2238.
22. Nawabi S, Bilal R, Javed MQ. Team-based learning versus Traditional lecture-based learning:An investigation of students'perceptions and academic achievements. Pak J Med Sci. 2021;37(4):1080–1085.
23. Wang MJ, Yang LZ, Yang WH. The perceived effectiveness of the blended team-based learning (BTBL) model on promoting intercultural awareness in hospitality education. Journal of Hospitality & Tourism Education. 2024 Jan 2;36(1):25-35. McCubbins OP, Paulsen TH, Anderson R. Examining student perceptions of their experience in a TBL formatted capstone course. J Agric Educ. 2018;59(1):135-152.
24. Church FC. Active learning: basic science workshops, clinical science cases, and medical role-playing in an undergraduate biology course. Education Sciences. 2021 ;11(8):370.
25. Lawlor J, Conneely C, Oldham E, Marshall K, Tangney B. Bridge21: teamwork, technology and learning. A pragmatic model for effective twenty-first-century team-based learning. Technology, Pedagogy and Education. 2018;27(2):211-32.
26. Stein RE, Colyer CJ, Manning J. Student accountability in team-based learning classes. Teaching Sociology. 2016;44(1):28-38.
27. Challa KT, Sayed A, Acharya Y. Modern techniques of teaching and learning in medical education: a descriptive literature review. MedEdPublish. 2021 ;10:18.