



EVALUATING THE EFFICACY OF TEAM-BASED LEARNING ON CONCEPTUAL UNDERSTANDING AND APPLICATION OF DENTAL MATERIALS SCIENCE IN A HYBRID CURRICULUM

Ambreen Azam¹, Farhat Kazmi², Amna Zulfiqar³, Kunza Naveed Asdaq⁴, Saba Farooq⁵, Hanzala Waqar⁶

¹BDS, MSc (UK), Assistant Professor, Department of Science of Dental Materials, Margalla College of Dentistry, Margalla Institute of Health Sciences

Email: ambshigri@gmail.com

²BDS, PhD, Professor, Department of Oral Pathology, Rashid Latif Dental College, Lahore

Email: drfarhatkazmi@gmail.com

³BDS, General Dentist, Al Shafi hospital, Rawalpindi

Email: amnasheikh1800@gmail.com

⁴BDS, M.Phil, Assistant Professor, Department of Science of Dental Materials, Margalla College of Dentistry, Margalla Institute of health sciences Rawalpindi

Email: kunzanaveed120@gmail.com

⁵BDS, MHPE Assistant Professor, Department of Medical Education Margalla College of Dentistry, Margalla Institute of health sciences, Rawalpindi

Email: sabazee@gmail.com

⁶ BDS, CHPE, MHPE (scholar), Lecturer Department of Medical Education Institute of Dental Sciences Kohat, Khyber Medical University

Email: hanzalawaqar93@gmail.com

Corresponding author: Farhat Kazmi

BDS, PhD Oral Pathology, Professor, Department of Oral Pathology, Rashid Latif Dental College, Lahore Email: drfarhatkazmi@gmail.com

Abstract

Objectives: There is a significant shift in the Saudi Arabian education system toward implementing innovative teaching and active learning strategies like Problem-Based Learning (PBL) and Team-Based Learning (TBL). At the College of Dentistry, Princess Nourah bint Abdulrahman University (CD-PNU), PBL along with didactic lectures are already part of its hybrid dental program. TBL was incorporated as an instructional strategy from the second to the final year. Since no published study in Saudi Arabia has yet addressed students' perception of TBL within a dental curriculum, this sequential explanatory mixed-methods study aims to evaluate the efficacy of TBL in fostering conceptual understanding and clinical application of Dental Materials Science. Specifically, we assessed student interest, perceived improvement in learning skills, and attitudes toward TBL as a student-centered methodology.

Methods: This sequential explanatory mixed-methods study was designed to analyze the inclusion of TBL in the Dental Materials Science course. The instrument was a modified, validated questionnaire covering two main areas: (1) teaching and learning in dental subjects, and (2) opinions towards TBL and its components. Quantitative data were collected using a 5-point Likert scale, with responses grouped into three categories for descriptive analysis. Qualitative data were collected via

two open-ended questions concerning the strengths and weaknesses of TBL. Descriptive statistics were used for the quantitative analysis, and thematic content analysis was applied to the open-ended responses, with frequency reporting to quantify the themes.

Results: A total of 131 students completed the TBL questionnaire (84% response rate). The results indicate that students found positive outcomes, reporting that TBL improved decision-making skills (74% agreement) and competence in self-directed learning (78% agreement). Qualitative themes highlighted the benefits of teamwork, structured preparation, and skills enhancement. Identified weaknesses included variable tutor involvement, content suitability, and the method of group selection.

Conclusion: TBL can be confidently incorporated with the current teaching methods adopted at CD-PNU. Students largely preferred this active student-centered method and found it satisfactory. The findings support TBL's utility in improving the conceptual understanding and clinical application skills necessary for Dental Materials Science. However, student concerns regarding session timings, group selection criteria, and need for faculty training require careful attention.

Keywords: Team-Based Learning; Dental Materials Science; Hybrid Curriculum; Active Learning; Conceptual Understanding; Clinical Application; Student Perception; Dental Education; Mixed-Methods Study

Introduction

The global landscape of health professional education, including dental and medical schools, is characterized by a significant shift from passive, didactic teaching to active learning methodologies [1]. These active tools, such as Problem-Based Learning (PBL) and Team-Based Learning (TBL), are known to create engaging learning environments based on critical analysis and discussion, thereby enhancing student learning outcomes. TBL, introduced by Larry Michaelsen in the 1970s [2], is a highly structured process consisting of three main phases: Independent Study, the Readiness Assurance Process (RAP), and Application Exercises. It is favored over methods like PBL due to its cost-effectiveness and scalability, managed by one instructor in a single classroom [3]. TBL has thus gained popularity in dental education worldwide.

In Saudi Arabia, the education system, though traditionally focused on didactic methods, is transitioning toward these innovative approaches. At the College of Dentistry, Princess Nourah bint Abdulrahman University (CD-PNU), a hybrid curriculum already incorporates PBL and didactic lectures. TBL was recently integrated as an instructional strategy from the second to the final year to further promote active learning.

However, Dental Materials Science presents a unique pedagogical challenge within the dental curriculum. It is a fundamental, technically heavy subject that demands a deep conceptual understanding of chemical and physical properties (e.g., setting reactions, mechanical characteristics). Critically, this knowledge must be immediately translated into clinical application (e.g., selecting the appropriate material or manipulation technique) [4]. Traditional didactic teaching often fails to bridge this gap, leading to student difficulty in applying theoretical concepts in a clinical context. TBL, with its emphasis on team problem-solving in the application phase, is uniquely positioned to foster the crucial clinical reasoning necessary for effective materials selection and use. While TBL's general benefits are documented, there is a lack of specific evidence on its efficacy in addressing the conceptual-to-application leap within the highly technical Dental Materials Science subject, particularly within the unique educational environment of Saudi Arabia. Therefore, this study was undertaken to evaluate the efficacy of TBL in fostering conceptual understanding and clinical application of Dental Materials Science principles, thereby contributing valuable evidence to both the global Medical Education literature and subject-specific pedagogy.

Materials and Methods

Study Design

This was a sequential explanatory mixed-methods study designed to evaluate student perception regarding the efficacy and implementation of TBL in the Dental Materials Science course within the hybrid dental curriculum at PNU. Ethical approval was obtained from the relevant ethical committee of the College of Dentistry, PNU.

Study Population

The study population included all undergraduate students from the second to the final year (D2, D3, D4, and D5) enrolled in the College of Dentistry, PNU, who participated in the TBL sessions.

Data Collection Instrument

A self-administered, online Google survey was designed and distributed. The questionnaire was adapted and modified from a validated instrument [5] and tested for content and clarity validity by a focused group. The instrument contained two distinct parts:

Quantitative Section: 20 items assessing students' general perception of teaching and learning in dental subjects and specific opinions toward TBL and its components (readiness assurance, team activities). All items used a 5-point Likert scale, where 1 = strongly disagree (SDA), 2 = disagree (DA), 3 = uncertain (UC), 4 = agree (A), and 5 = strongly agree (SA).

Qualitative Section: Two open-ended questions designed to analyze the perceived strengths and weaknesses of the TBL teaching methodology.

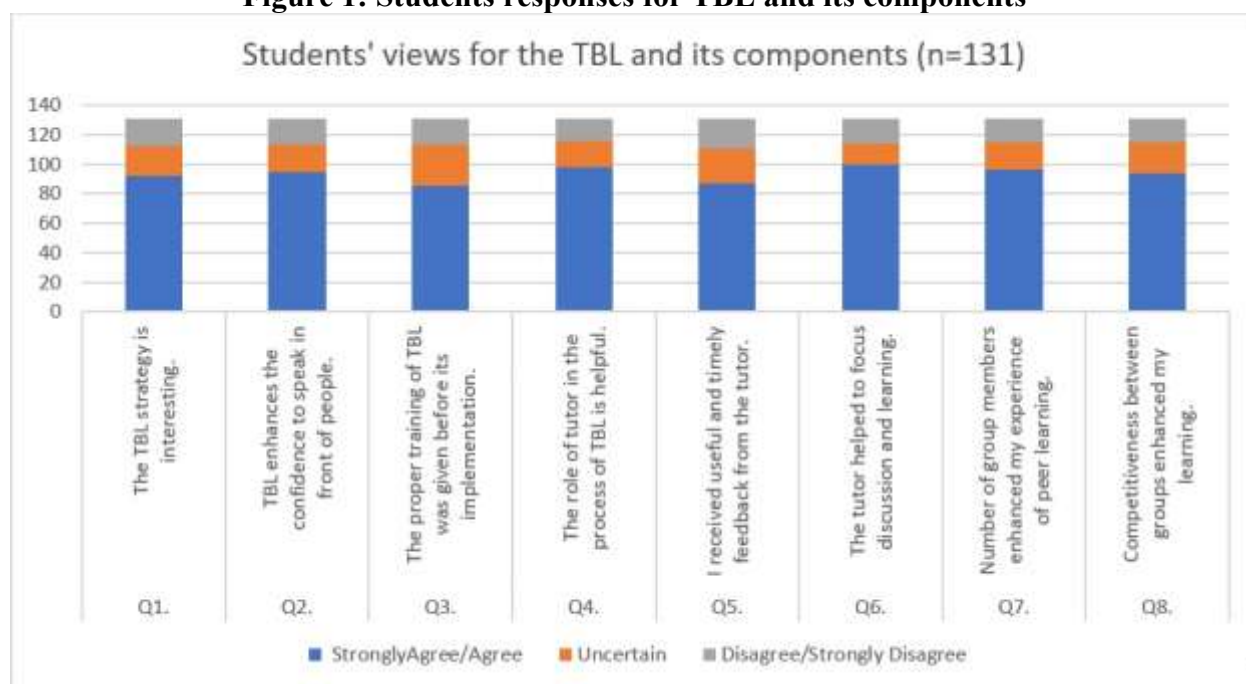
Data Analysis

Data analysis utilized both quantitative and qualitative techniques. Quantitative data (Likert items) were analyzed using descriptive statistics, including frequencies and percentages. For clarity of reporting, the 5-point responses were grouped into three categories: Strongly Agree/Agree, Uncertain, and Disagree/Strongly Disagree. The qualitative data (open-ended responses) were analyzed using thematic content analysis [6]. Recurring themes were identified, coded, and the frequency of student comments supporting each theme was quantified and reported to provide a deeper explanatory context for the overall quantitative findings (mixed-methods integration).

Results

A total of 131 students completed the TBL questionnaire out of 156, achieving a response rate of 84%. The distribution across academic years was D2 (34), D3 (39), D4 (32), and D5 (26).

Figure 1: Students responses for TBL and its components



Quantitative Findings:

The majority of participants found the TBL sessions to be interesting and motivating. Critical findings directly related to application skills included:

Table 1: Students' responses regarding learning through TBL in dental materials course

No.	Questions	1 n (%)	2 n (%)	3 n (%)
Q1.	TBL improves the decision-making skills.	97(74.04)	18(13.74)	16(12.21)
Q2.	TBL develops the competence in self-directed learning.	102(77.86)	15(11.45)	14(10.68)
Q3.	Problem solving allowed me to develop my clinical reasoning skills.	93(71)	19(14.50)	19(14.50)
Q4.	All team members tried to participate in the discussion.	101(77.09)	15(11.45)	15(11.45)
Q5.	Team members encouraged each other to express their opinion.	102(77.86)	15(11.45)	14(10.68)
Q6.	Different point of views was respected by team members.	101(77.09)	16(12.21)	14(10.68)
Q7.	This team activity elicited multiple point of views before deciding on a final answer.	98(74.80)	16(12.21)	17(12.97)
Q8.	All team members consistently paid attention during group discussions.	101(77.09)	17(12.97)	13(9.92)
Q9.	Team members used feedback about individual and team performance to help the team be more effective.	87(66.41)	21(16.03)	23(17.55)
Q10.	Students did read the readings prior to the session.	96(73.28)	19(14.50)	16(12.21)
Q11.	Completion of the out of class preparation assisted in my learning.	95 (72.51)	20(15.26)	16(12.21)
Q12.	The individual and team tests at the beginning of class assisted in my learning.	94(71.75)	19(14.50)	18(13.74)
1: Strongly Agree/Agree, 2: Uncertain, 3: Strongly Disagree/Disagree				
74% of students thought that TBL improves decision-making skills.				
71% of students agreed that problem-solving allowed them to develop their clinical reasoning skills.				
78% of participants were of the opinion that TBL develops competence in self-directed learning.				
73% of students agreed that they read the materials prior to the session, indicating TBL successfully promoted pre-session preparation.				
75% of students agreed that the role of the tutor in the process of TBL is helpful				

Qualitative Findings (Strengths and Weaknesses)

The thematic content analysis of the open-ended questions provided explanatory context for the quantitative results:

Table 2: Thematic Analysis for TBL strength and weakness based on student comments

Theme	Student comments	Total responses
Best features of TBL identified by students		
<i>Teamwork</i>	Sharing knowledge with few group members helped me in understanding the material more	41/131

Students liked discussion in small groups of 5-6 students	Improve my discussion skills in a smaller group	19/131
All groups working under one roof also aided in better learning	I liked working in teams and hearing different group opinions	75/131
More focused	Reading before session helped me answer questions with the group	56/131
Students found TBL more structured and mentioned the pre session readings helpful in focusing on the topic	Pre reading material helped me search for more information	27/131
	Individual and team tests helped me clear my concepts and fill my knowledge gaps	32/131
	I liked the starting quiz and its explanation after	12/131
Presence of Subject expert	I was happy to have my teacher around	44/131
Students found experts presence more fruitful	Immediate feedback by the subject teacher cleared my concepts	
	I was satisfied that I will get the right answers as my teacher was present	23/131
Enjoyable learning with skill enhancement	TBL was very interesting and made learning easy	75/131
	Nice activity to display skills	34/131
	Improved my discussion and reasoning skills in less time as I have to study many times when I am studying alone	
	Better problem solving with competitiveness between teams	
	Improved my critical thinking and clinical reasoning	
Weak aspects of TBL identified by students		
Pre reading material	We were given long readings to for a new topic it was hard	34/131
	Pre reading was sent late it should be sent a week ago	39/131
Topic selection	sometimes the material can be too much and very difficult for us to understand so I suggest if the doctors try to choose a relatively easy material for the TBL sessions and save the hard ones for regular lectures	26/131
Type of topic chosen for TBL	Not all topics are suitable for TBL	17/131
Group selection	Sometimes I don't like working with the team I am included	20/131
Students want to select their own team	Random selection of groups was not beneficial	9/131
Tutor involvement	Faculty should be trained more as I did not like one session which was not organized well	49/131
Presence of experienced tutor was liked but sometimes the involvement was more than needed	Few of my questions were not answered and remained open ended	32/131
	Too much explanation by the tutor confused me	

Timings of the session Students suggested to increase the session time for completing all activities	The adequate time should be giving to make the most effective discussion	35/131
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Discussion

The present sequential explanatory mixed-methods study assessed the perception of undergraduate dental students toward TBL, finding overwhelmingly positive outcomes. The findings demonstrate that TBL is a satisfactory, effective, and efficient method of learning.

The high agreement regarding improvement in decision-making skills (74% agreement) and clinical reasoning skills (71% agreement) is a critical contribution. This supports the efficacy of TBL specifically for subjects like Dental Materials Science, where the objective is not just memorization but the application of complex material properties to solve real-life clinical scenarios, such as selecting the appropriate restorative cement or impression material [4]. TBL's reliance on small group interactions and its structured components are crucial in enhancing these decision-making skills in a low-risk environment.

The qualitative results reinforced these findings, showing that teamwork and discussion were highly valued by students. This confirms TBL's success in promoting active participation and peer teaching, vital components of modern Medical Education [3]. Furthermore, the high agreement (73%) for pre-session preparation suggests TBL successfully structured students' learning. This ensures mastery of the theoretical conceptual understanding of material properties before team application, thereby optimizing the TBL session for the high-level application required in Dental Materials Science.

However, the qualitative data also provided necessary insight into areas for refinement. The dissatisfaction expressed with random group selection (29/131 comments) and the suggestion to increase session timings (35/131 comments) are crucial feedback points. While TBL literature often advocates for random grouping to mimic clinical team dynamics, addressing student concerns is necessary for acceptance and continuous improvement of the TBL methodology.

Finally, while 75% of students found the tutor's role helpful, the qualitative comments (49/131 comments regarding tutor involvement) indicated a need for consistent faculty training. Some students felt the tutor's involvement was excessive, leading to lengthy explanations that caused confusion. This underscores the need for continuous professional development for educators to ensure they act as effective facilitators during TBL application exercises rather than reverting to didactic lecturing.

Conclusion

We conclude that TBL can be incorporated with confidence with the current teaching methods adopted at the College of Dentistry, PNU. Introducing TBL as an active, student-centered teaching method was found to be satisfactory, demonstrably contributing to the conceptual understanding and clinical application skills necessary for Dental Materials Science. However, student concerns regarding group selection criteria, the need to increase session timings, and continuous faculty training must be addressed carefully to optimize the TBL experience.

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