European Journal of Clinical Pharmacy
Print ISSN: 2385-409X **Online ISSN**: 3105-0409
Website: https://farmclin.com/

Original Research Article

Beyond the Lecture: A Comparative Analysis of Active Learning Interventions in Foundational Science Modules and Their Impact on Student Engagement and Performance

Article History:

Name of Author:
Dr. Summyia Sadia[1], Dr Ayesha Ghassan[2], Dr. Tayyeba Iftikhar Mirza[3], Muhammad Nazir[4], Dr. Saba Abrar[5] and Dr. Rizwana yaseen[6]

Affiliation: [1]*Professor Rai medical college Sargodha*
[2]*Assistant Professor Watim Medical college*
[3]*Associate Professor, Department of Medical Education, Foundation University Islamabad*
[4]*Assistant Professor Bhitai Dental & Medical College*
[5]*Associate Professor Department of physiology Baqai Medical University*
[6]*Senior Lecturer Baqai medical college & University*

Corresponding Author:
Summyia Sadia

Received: 28-11-2025
Revised: 05-12-2025
Accepted: 12-01-2026
Published: 28-01-2026

Abstract: ***Aim of Study***: This study aimed to compare the effectiveness of two active learning pedagogies—Team-Based Learning (TBL) and Case-Based Learning (CBL)—against traditional didactic lectures (TL) in foundational science modules, specifically assessing their impact on student engagement and academic performance. ***Study Duration***: July 2024 to July 2025. ***Study Place***: Rai Medical College Sargodha ***Methodology***: A quasi-experimental, non-equivalent control group design was employed. First-year medical students (n=180) were assigned to three groups: TBL (n=60), CBL (n=60), and TL (control, n=60). The intervention was delivered across two sequential modules (Biochemistry and Physiology). Engagement was measured using the validated Classroom Engagement Survey (CES) at three time points. Academic performance was assessed via structured module-end examinations featuring Multiple Choice Questions (MCQs) and Short Answer Questions (SAQs). Data were analyzed using ANOVA, post-hoc tests, and Pearson's correlation. ***Results***: Both TBL and CBL groups demonstrated significantly higher mean engagement scores (TBL: 4.25 ± 0.41; CBL: 4.10 ± 0.39) compared to the TL group (3.20 ± 0.52) ($p<0.001$). Academically, the TBL group achieved the highest mean exam scores (86.4 ± 5.2), followed by CBL (83.1 ± 5.8) and TL (78.5 ± 6.7), with significant intergroup differences ($p<0.01$). A strong positive correlation was found between engagement scores and exam performance ($r=0.72$, $p<0.001$). ***Conclusion***: Active learning pedagogies, particularly TBL, are superior to traditional lectures in enhancing both student engagement and academic performance in foundational medical sciences. Curriculum developers should prioritize integrating structured active learning strategies to enhance deeper understanding and better learning outcomes.

Keywords: Active Learning; Team-Based Learning; Case-Based Learning; Medical Education; Student Engagement; Academic Performance; Foundational Sciences.

INTRODUCTION

The landscape of medical education is undergoing a paradigm shift, moving away from the passive knowledge transmission characteristic of traditional didactic lectures towards dynamic, student-centered learning models [1]. This transition is driven by growing evidence that deep, enduring understanding and clinical competency in medical students and doctors can be achieved through active engagement, critical thinking, and collaborative problem-solving [2,3]. Foundational science modules—such as Biochemistry, Physiology, and Anatomy—form the critical bedrock of medical knowledge. However, students often perceive these subjects as dense, abstract, and disconnected from clinical practice, leading to disengagement and surface-level learning [4]. The challenge for contemporary medical educators is to deliver this essential content in ways that not only convey complex information but also stimulate intellectual curiosity, promote retention, and facilitate the application of basic science principles to clinical scenarios [5].

Traditional lecture-based teaching (TL), while efficient for delivering large volumes of information to large student audience, has been increasingly criticized for creating a passive learning environment. The traditional lecture positions the student as a mere receiver of information, which can lead to cognitive overload, limited attention spans, and inadequate development of higher-order thinking skills like analysis, synthesis, and evaluation [6,7]. In contrast, active learning pedagogies rest on the constructivist theory that learners build knowledge and meaning through experiences and social discourse [8]. These strategies require students to engage cognitively and interactively with the material, their peers, and the instructor. Two prominent and well-structured active learning approaches are Team-Based Learning (TBL) and Case-Based Learning (CBL).

Team-Based Learning is a collaborative instructional strategy with a fixed sequence: preparatory self-study, individual and team Readiness Assurance Tests (iRAT & tRAT), and application-oriented team exercises [9]. It emphasizes accountability, both individual and team-based, and uses feedback to clarify misconceptions. Its structured nature promotes pre-class preparation and in-class peer teaching, making it highly scalable even for large classes [10]. The other approach, the Case-Based Learning, rooted in the Harvard Business School model and adapted for medicine, uses authentic, detailed clinical cases as the focal point for learning [11]. Students, often in small groups, analyze the case, identify learning issues, apply foundational science knowledge to explain clinical findings, and propose solutions. CBL is praised for enhancing clinical reasoning, integrating basic and clinical sciences early, and increasing perceived relevance [12].

The core metrics for evaluating the success of these pedagogical interventions are student engagement and academic performance. Engagement is a multi-faceted construct that includes behavioral (participation, effort), emotional (interest, value), and cognitive (deep learning, self-regulation, and reflection) dimensions [13]. High engagement is a great predictor of academic success, and professional development [14]. Performance, which is typically measured through assessments, indicates the degree of knowledge acquisition, comprehension, and application.

While a substantial body of literature advocates for effectiveness of active learning in STEM and medical education in general [15,16], there is still a need for more direct comparative studies within specific, high-stakes contexts like foundational medical sciences, especially in a South Asian setting. Many studies either isolate a single active learning method against lectures or combine various techniques, making it difficult to determine the specific efficacy and practical implications of a distinct, well-defined intervention like TBL and CBL [17]. In addition, the relationship between the specific type of pedagogical engagement elicited and the nature of academic performance (e.g., recall vs. application-based questions) warrants closer examination [18].

This study, therefore, tries to address these gaps by conducting a controlled comparative analysis at Rai Medical College, Sargodha. It is hypothesized that: 1) Students in TBL and CBL groups will report significantly higher levels of overall engagement compared to those in the TL group; 2) Students in TBL and CBL groups will achieve significantly higher scores on module-end examinations; and 3) There will be a significant positive correlation between students' engagement scores and their academic performance. By clarifying the differential impacts of TBL and CBL on engagement and performance, this research aims to provide empirical evidence to guide faculty development and strategic curriculum reform in medical institutions, ultimately contributing to the cultivation of more competent, engaged, and self-directed future physicians [19,20].

METHODOLOGY

Study Design and Setting: A quasi-experimental, non-equivalent control group design was implemented over one academic year (July 2024 – July 2025) at Rai Medical College, Sargodha. The study compared three instructional strategies across two sequential foundational science modules: Biochemistry (Module 1) and Physiology (Module 2).

Participants and Sampling: The target population was all first-year Bachelor of Medicine, Bachelor of Surgery (MBBS) students (N=180). Using a convenience sampling technique, the entire cohort was allocated into three non-randomized but demographically balanced groups of 60 students each, based on their pre-assigned tutorial groups to minimize logistical disruption and cross-contamination. Group A experienced Team-Based Learning (TBL), Group B experienced Case-Based Learning (CBL), and Group C served as the control, receiving Traditional Lectures (TL). Informed written consent was obtained from all participants.

Interventions:

1. **Traditional Lecture (TL) Group:** Received standard, instructor-led didactic lectures using PowerPoint presentations, with limited opportunity for student questioning.
2. **Team-Based Learning (TBL) Group:** For each module unit, students completed pre-assigned readings. In class, they first took an individual Readiness Assurance Test (iRAT) of 10 MCQs, followed by the same test taken as a team (tRAT) using immediate feedback assessment technique (IF-AT) cards. The major portion of the session was dedicated to

complex, application-focused team exercises on the same topic.

3. **Case-Based Learning (CBL) Group:** Prior to class, students received a clinical case narrative. During 2-hour sessions, facilitated by a tutor, groups of 8-10 students analyzed the case, identified pathophysiological mechanisms linked to foundational sciences, formulated learning objectives, and presented their conclusions.

Data Collection Tools and Variables:
Independent Variable: Instructional pedagogy (TBL, CBL, TL).

Dependent Variables:
Student Engagement: Measured using a validated 20-item Classroom Engagement Survey (CES) on a 5-point Likert scale (1=Strongly Disagree, 5=Strongly Agree). The CES covered behavioral, emotional, and cognitive subscales. It was administered at the midpoint and end of each module (Time 1: Mid-Biochemistry; Time 2: End-Biochemistry; Time 3: End-Physiology).

Academic Performance: Assessed via a structured, standardized end-of-module examination for both Biochemistry and Physiology. Each exam contained 70% MCQs (testing recall and application) and 30% SAQs (testing integration and explanation). Scores were converted to percentages.

Demographic Data: Age, gender, and pre-admission academic scores were collected at baseline.

Data Analysis: Data were analyzed using SPSS version 26.0. Descriptive statistics (mean, standard deviation, frequency) summarized demographics and key variables. One-way Analysis of Variance (ANOVA) was used to compare mean engagement scores and exam scores across the three groups, followed by Tukey's HSD post-hoc test for pairwise comparisons. Pearson's correlation coefficient was calculated to assess the relationship between overall mean engagement scores and total mean exam scores. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 180 students participated, with a mean age of 19.2 ± 0.8 years; 52% were female. The groups were comparable at baseline regarding age, gender distribution, and pre-admission scores (p>0.05).

Table 1: Demographic Characteristics of Study Participants (N=180)

Characteristic	TBL Group (n=60)	CBL Group (n=60)	TL Group (n=60)	p-value
Age (Years), Mean ± SD	19.1 ± 0.7	19.3 ± 0.9	19.2 ± 0.8	0.451
Gender, n (%)				0.872
Male	29 (48.3%)	28 (46.7%)	30 (50.0%)	
Female	31 (51.7%)	32 (53.3%)	30 (50.0%)	
Pre-admission Score (%), Mean ± SD	85.6 ± 4.1	84.9 ± 4.5	85.2 ± 4.3	0.689

Table 1*: The baseline demographic and academic characteristics of the 180 first-year medical students distributed across the three intervention groups: Team-Based Learning (TBL), Case-Based Learning (CBL), and Traditional Lecture (TL). The statistical analysis (ANOVA for age and scores, Chi-square for gender) shows no significant differences (p>0.05) between the groups in terms of mean age, gender proportion, or pre-admission academic scores. This comparability is crucial as it strengthens the internal validity of the study by suggesting that any differences observed in engagement or performance outcomes are more likely attributable to the pedagogical interventions rather than pre-existing differences in the student cohorts.*

Table 2: Comparison of Mean Student Engagement Scores Across Groups

Group	Time 1 (Mid-Biochem) Mean ± SD	Time 2 (End-Biochem) Mean ± SD	Time 3 (End-Physio) Mean ± SD	**Overall Mean Engagement ± SD**
TBL (n=60)	4.15 ± 0.45	4.28 ± 0.40	4.32 ± 0.38	**4.25 ± 0.41**
CBL (n=60)	4.02 ± 0.42	4.12 ± 0.38	4.16 ± 0.37	**4.10 ± 0.39**
TL (n=60)	3.15 ± 0.60	3.20 ± 0.55	3.25 ± 0.50	**3.20 ± 0.52**
p-value (ANOVA)	<0.001	<0.001	<0.001	**<0.001**

Table 2: The mean engagement scores for the three groups measured at three different intervals during the study. A consistent and statistically significant pattern is evident (p<0.001 at all-time points). The TBL group consistently reported the highest engagement, followed closely by the CBL group, while the TL group reported the lowest engagement. The overall mean engagement score, calculated by averaging the three time points, was highest for TBL (4.25), then CBL (4.10), and lowest for TL (3.20). This clear gradient indicates that both structured active learning pedagogies were substantially more effective in fostering student engagement across an entire academic module compared to traditional lectures. The slight increase in scores over time for all groups may reflect growing familiarity with the learning environment.

Table 3: Comparison of Academic Performance (Module End Exam Scores)

Group	Biochemistry Exam (% Score, Mean ± SD)	Physiology Exam (% Score, Mean ± SD)	**Combined Mean Exam Score ± SD**
TBL (n=60)	85.8 ± 5.5	87.0 ± 4.9	**86.4 ± 5.2**
CBL (n=60)	82.5 ± 6.0	83.7 ± 5.6	**83.1 ± 5.8**
TL (n=60)	77.9 ± 7.0	79.1 ± 6.4	**78.5 ± 6.7**
p-value (ANOVA)	<0.001	<0.001	**<0.001**

Table 3: The key outcome of academic performance, measured by standardized end-of-module examination scores. The results mirror the engagement findings. The TBL group achieved the highest mean scores in both Biochemistry (85.8%) and Physiology (87.0%), resulting in the highest combined mean score (86.4%). The CBL group performed better than the TL group but lower than the TBL group, with a combined mean of 83.1%. The TL (control) group had the lowest performance (combined mean 78.5%). The ANOVA results confirm that the differences in mean scores across the three groups are statistically highly significant (p<0.001). Post-hoc Tukey tests (not shown in table) confirmed that all pairwise comparisons (TBL vs. CBL, TBL vs. TL, CBL vs. TL) were also statistically significant (p<0.01), indicating that each pedagogical approach yielded a distinct level of academic performance.

Table 4: Correlation between Overall Engagement and Academic Performance

Variable	1	2
1. Overall Mean Engagement Score	1	
2. Combined Mean Exam Score	**0.72****	1
*Note: ** Correlation is significant at the 0.001 level (2-tailed).*		

Table 4: Table 4 displays the Pearson correlation coefficient analyzing the relationship between students' overall engagement and their academic performance, pooling data from all 180 participants regardless of group. The analysis reveals a strong, positive, and statistically significant correlation ($r = 0.72$, $p < 0.001$). This indicates that higher levels of self-reported classroom engagement are associated with higher scores on summative examinations. This finding supports the theoretical construct that engaged learning—characterized by active participation, interest, and cognitive investment—directly translates into superior knowledge acquisition and demonstration. It strengthens the argument that pedagogical strategies enhancing engagement are likely to yield better academic outcomes.

Graph 1: Trend of Mean Engagement Scores Over Time by Group

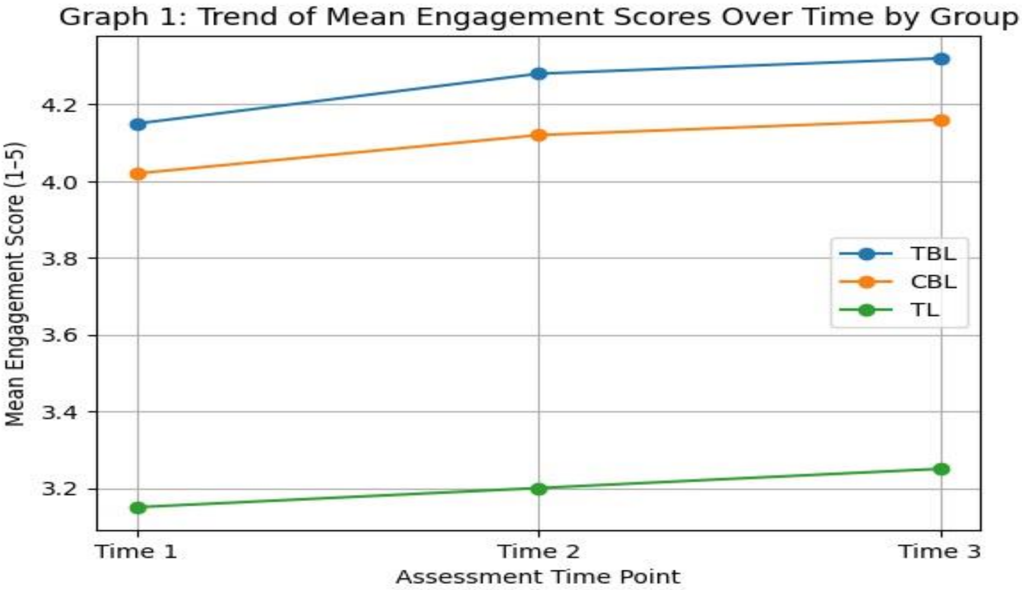

Figure 1: The longitudinal data from Table 2, illustrating the trend of engagement for each group across the three measurement periods. It clearly shows the sustained and substantial gap between the active learning groups (TBL and CBL) and the traditional lecture group (TL) throughout the study duration. The near-parallel, slightly ascending lines suggest that the benefits of the active learning approaches on engagement were immediate and persisted, even slightly amplifying over time. The graph reinforces that the difference is not a transient effect but a stable outcome of the pedagogical environment.

Graph 2: Comparison of Combined Mean Exam Scores by Group

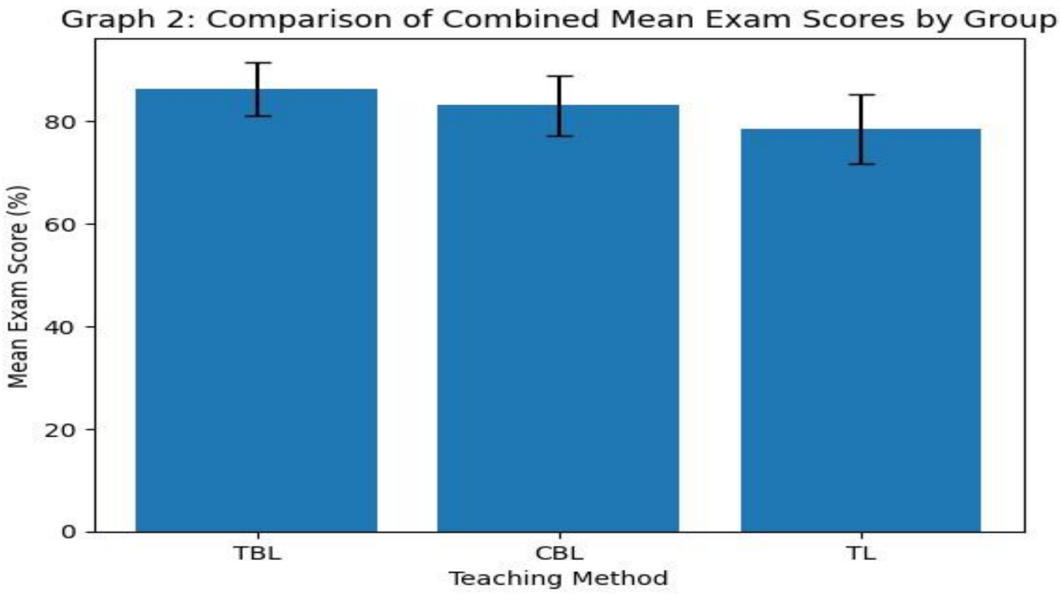

Figure 2: Comparison of the primary academic outcome—combined exam performance—across the three pedagogical

approaches. The height of each bar corresponds directly to the combined mean score from Table 3. The error bars (showing standard deviation) indicate the spread of scores within each group. The chart effectively communicates the performance hierarchy: TBL leading, followed by CBL, with TL trailing. It offers an intuitive grasp of the magnitude of the performance difference achieved through active learning strategies, particularly TBL.

DISCUSSION

The findings of this study provide empirical support for the efficacy of structured active learning pedagogies, specifically Team-Based Learning (TBL) and Case-Based Learning (CBL), over traditional didactic lectures in the context of foundational medical sciences. The results confirm all three research hypotheses, showing significant enhancements in both student engagement and academic performance, with a positive correlation between these two critical educational outcomes.

The significantly higher engagement scores in the TBL and CBL groups align with a large body of literature advocating for learner-centered environments [1,13]. The structured interdependence and accountability mechanisms in TBL—through the iRAT/tRAT sequence and team application exercises—likely triggered a combination of behavioral (preparation, participation), cognitive (peer explanation, problem-solving), and emotional (team support, reduced anonymity) engagement [9,10]. CBL, by anchoring learning in pre-clinical narratives, successfully enhanced the perceived relevance of foundational sciences, thereby boosting emotional and cognitive engagement as students worked to solve clinical problems [11,12]. In contrast, the passive nature of the TL environment offered fewer avenues for such multi-dimensional engagement, resulting in significantly lower scores. Our longitudinal data (Graph 1) further suggests that these engagement benefits are sustainable over a course of a module.

The academic performance of the TBL and CBL groups, particularly the top performance of the TBL group, is an important finding. This extends the work of meta-analyses like that by Freeman et al. [15], which demonstrated that active learning boosts STEM exam scores, by providing a direct comparison of two specific, scalable methods within medical education. The performance advantage can be attributed to several factors aligned with cognitive science principles. Both TBL and CBL employ *retrieval practice* (through tests and case discussions) and *spaced repetition*, which are known to strengthen memory consolidation [21]. More importantly, they enforce *elaborative rehearsal*—students must explain concepts to peers (TBL) or apply them to explain clinical findings (CBL). This process of generating explanations deepens understanding and creates more robust neural pathways, leading to better performance on assessments that test application and integration, as our exams did [22]. The slightly higher performance of TBL over CBL may be due to its more systematic and repeated testing component (iRAT/tRAT), which provides immediate feedback and forcefully identifies knowledge gaps for every student at the start of each unit [23].

The significant positive correlation (r=0.72) between engagement and performance is a powerful integrative finding. It moves beyond merely showing that two desirable outcomes co-occur and suggests a likely causative relationship where the pedagogical model drives engagement, which in turn facilitates deeper learning and superior performance [14,24]. This underscores that engagement is not merely a "soft" or subjective metric but a true mediator of academic success. Therefore, pedagogical choices that increase engagement should be viewed as direct measure of learning outcomes.

This study has several implications. For curriculum designers, it argues strongly for replacing or supplementing large-block lectures in foundational sciences with structured active learning sessions. This has already been recommended by the Pakistan Medical and Dental Council [26] as TBL appears particularly effective for ensuring uniform baseline knowledge and developing teamwork skills, while CBL excels at early clinical integration. Faculty development programs must therefore equip educators with the skills to design and facilitate these sessions effectively [19]. For students, these methods, though initially demanding due to required preparation, ultimately lead to more satisfying learning experiences and better preparation for licensing exams and clinical rotations as well as their preparation for a clinical situation.

Limitations of this study include its single-institution setting and use of non-randomized groups, which may affect generalizability. While groups were demographically similar, hidden confounding variables cannot be entirely ruled out. Furthermore, engagement was self-reported, which may introduce bias. Future research should employ multi-institutional randomized designs, incorporate objective measures of engagement (e.g., classroom analytics), and conduct long-term follow-up to assess knowledge retention and impacts on clinical performance in later years [25]. Investigating the specific cognitive load experienced by students in these different settings would also be valuable [18].

In conclusion, this study adds credible evidence from a Pakistani medical school to the global consensus on active learning. It demonstrates that moving "beyond the lecture" through pedagogies like TBL and CBL is not just a trendy shift but a empirically validated strategy to cultivate more engaged, high-performing medical students from the very foundation of their training.

CONCLUSION

This comparative study conclusively demonstrates that active learning pedagogies, specifically Team-Based

Learning and Case-Based Learning, significantly outperform traditional lecture-based instruction in enhancing both student engagement and academic performance within foundational science modules of a medical curriculum. TBL emerged as the most effective strategy in this context, yielding the highest scores on both metrics. The strong correlation found between engagement and performance reinforces the theoretical link between active participation and deep learning. These findings advocate for a strategic redesign of medical education curricula to integrate structured, interactive learning experiences that promote accountability, collaboration, and clinical relevance from the earliest stages of training. Such a shift is essential for preparing future physicians who are not only knowledgeable but also adept at critical thinking and lifelong learning.

REFERENCES

1. Taylor, D. C. M., & Hamdy, H. (2013). Adult learning theories: Implications for learning and teaching in medical education. *Medical Teacher*, *35*(11), e1561-e1572. https://doi.org/10.3109/0142159X.2013.828153
2. Spencer, J. A., & Jordan, R. K. (1999). Learner centred approaches in medical education. *BMJ*, *318*(7193), 1280-1283. https://doi.org/10.1136/bmj.318.7193.1280
3. Mehta, N. B., Hull, A. L., Young, J. B., & Stoller, J. K. (2013). Just imagine: New paradigms for medical education. *Academic Medicine*, *88*(10), 1418-1423. https://doi.org/10.1097/ACM.0b013e3182a36a07
4. Finnerty, E. P., Chauvin, S., Bonaminio, G., Andrews, M., Carroll, R. G., & Pangaro, L. N. (2010). Flexner revisited: The role and value of the basic sciences in medical education. *Academic Medicine*, *85*(2), 349-355. https://doi.org/10.1097/ACM.0b013e3181c88b09
5. Kulasegaram, K. M., & Rangachari, P. K. (2018). Beyond "formative": Assessments to enrich student learning. *Advances in Physiology Education*, *42*(1), 5-14. https://doi.org/10.1152/advan.00122.2017
6. Prober, C. G., & Heath, C. (2012). Lecture halls without lectures—a proposal for medical education. *New England Journal of Medicine*, *366*(18), 1657-1659. https://doi.org/10.1056/NEJMp1202451
7. Bate, E., Hommes, J., Duvivier, R., & Taylor, D. C. M. (2014). Problem-based learning (PBL): Getting the most out of your students – Their roles and responsibilities. *Medical Teacher*, *36*(1), 1-12. https://doi.org/10.3109/0142159X.2014.848269
8. Dolmans, D. H. J. M., De Grave, W., Wolfhagen, I. H. A. P., & Van Der Vleuten, C. P. M. (2005). Problem-based learning: Future challenges for educational practice and research. *Medical Education*, *39*(7), 732-741. https://doi.org/10.1111/j.1365-2929.2005.02205.x
9. Michaelsen, L. K., & Sweet, M. (2008). The essential elements of team-based learning. *New Directions for Teaching and Learning*, *2008*(116), 7-27. https://doi.org/10.1002/tl.330
10. Parmelee, D., Michaelsen, L. K., Cook, S., & Hudes, P. D. (2012). Team-based learning: A practical guide: AMEE Guide No. 65. *Medical Teacher*, *34*(5), e275-e287. https://doi.org/10.3109/0142159X.2012.651179
11. Thistlethwaite, J. E., Davies, D., Ekeocha, S., Kidd, J. M., MacDougall, C., Matthews, P., ... & Clay, D. (2012). The effectiveness of case-based learning in health professional education. A BEME systematic review: BEME Guide No. 23. *Medical Teacher*, *34*(6), e421-e444. https://doi.org/10.3109/0142159X.2012.680939
12. McLean, S. F. (2016). Case-based learning and its application in medical and healthcare fields: A review of worldwide literature. *Journal of Medical Education and Curricular Development*, *3*, JMECD.S20377. https://doi.org/10.4137/JMECD.S20377
13. Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, *74*(1), 59-109. https://doi.org/10.3102/00346543074001059
14. Carini, R. M., Kuh, G. D., & Klein, S. P. (2006). Student engagement and student learning: Testing the linkages. *Research in Higher Education*, *47*(1), 1-32. https://doi.org/10.1007/s11162-005-8150-9
15. Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences*, *111*(23), 8410-8415. https://doi.org/10.1073/pnas.1319030111
16. Burgess, A., Bleasel, J., Haq, I., Roberts, C., Garsia, R., Robertson, T., & Mellis, C. (2017). Team-based learning (TBL) in the medical curriculum: better than PBL? *BMC Medical Education*, *17*(1), 243. https://doi.org/10.1186/s12909-017-1068-z

17. Koles, P., Nelson, S., Stolfi, A., Parmelee, D., & DeStephen, D. (2005). Active learning in a Year 2 pathology curriculum. *Medical Education, 39*(10), 1045-1055. https://doi.org/10.1111/j.1365-2929.2005.02248.x
18. Leppink, J., & van den Heuvel, A. (2015). The evolution of cognitive load theory and its application to medical education. *Perspectives on Medical Education, 4*(3), 119-127. https://doi.org/10.1007/s40037-015-0192-x
19. Steinert, Y., Mann, K., Anderson, B., Barnett, B. M., Centeno, A., Naismith, L., ... & Dolmans, D. (2016). A systematic review of faculty development initiatives designed to enhance teaching effectiveness: A 10-year update. *Medical Teacher, 38*(8), 769-786. https://doi.org/10.1080/0142159X.2016.1181851
20. Irby, D. M., Cooke, M., & O'Brien, B. C. (2010). Calls for reform of medical education by the Carnegie Foundation for the Advancement of Teaching: 1910 and 2010. *Academic Medicine, 85*(2), 220-227. https://doi.org/10.1097/ACM.0b013e3181c88449
21. Larsen, D. P., Butler, A. C., & Roediger III, H. L. (2013). Comparative effects of test-enhanced learning and self-explanation on long-term retention. *Medical Education, 47*(7), 674-682. https://doi.org/10.1111/medu.12141
22. Fiorella, L., & Mayer, R. E. (2016). Eight ways to promote generative learning. *Educational Psychology Review, 28*(4), 717-741. https://doi.org/10.1007/s10648-015-9348-9
23. Sisk, R. J. (2011). Team-based learning: Systematic research review. *Journal of Nursing Education, 50*(12), 665-669. https://doi.org/10.3928/01484834-20111017-01
24. Lizzio, A., Wilson, K., & Simons, R. (2002). University students' perceptions of the learning environment and academic outcomes: implications for theory and practice. *Studies in Higher Education, 27*(1), 27-52. https://doi.org/10.1080/03075070120099359
25. Haidet, P., Levine, R. E., Parmelee, D. X., Crow, S., Kennedy, F., Kelly, P. A., ... & Richards, B. F. (2012). Perspective: Guidelines for reporting team-based learning activities in the medical and health sciences education literature. *Academic Medicine, 87*(3), 292-299. https://doi.org/10.1097/ACM.0b013e318244759e
26. Pakistan Medical & Dental Council. (2023). Curriculum of MBBS 2023-24. Islamabad: PMDC

