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COMPARING THE EFFECTIVENESS OF PROBLEM-BASED LEARNING AND FLIPPED CLASSROOM MODELS IN ENHANCING CRITICAL THINKING AMONG MEDICAL STUDENTS

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ABSTRACT

Objective: *To compare the effectiveness of Problem-Based Learning and Flipped Classroom models in enhancing critical thinking among third-year medical students.*

Methods: *This quasi-experimental study was conducted at a private medical college in Rawalpindi, Pakistan, from March to May 2025. A purposive sample of 120 third-year MBBS students was divided into two equal groups: PBL and FC. Both groups received instruction using the same clinical content delivered through different pedagogical approaches. Critical thinking was assessed using the California Critical Thinking Skills Test (CCTST) before and after a four-week instructional period. Descriptive statistics, paired sample t-tests, and independent sample t-tests were used for data analysis using SPSS version 25, with a significance level set at $p < 0.05$.*

Results: *Students in the PBL group demonstrated significantly higher post-intervention critical thinking scores ($M = 49.84$, $SD = 13.42$) compared to their pre-test scores ($M = 37.44$, $SD = 6.86$; $t = -4.571$, $p = .000$). Similarly, the FC group showed a significant increase (pre-test $M = 29.04$, $SD = 7.40$; post-test $M = 36.72$, $SD = 9.58$; $t = -5.136$, $p = .000$). However, PBL yielded greater cognitive gains and higher engagement across participation indicators including class discussion, assignments, and presentations.*

Conclusion: *Both PBL and FC approaches significantly enhanced students' critical thinking, but PBL proved to be more effective. The interactive and problem-solving nature of PBL likely contributed to deeper cognitive engagement and skill development. These findings support the broader integration of PBL in medical curricula and suggest that blended models could optimize critical thinking outcomes.*

Keywords: *Problem-Based Learning, Flipped Classroom, Critical Thinking, Medical Education, Instructional Methods, Cognitive Skills, Pakistan.*

INTRODUCTION

Critical thinking is regarded as a foundational skill in medical education, essential for diagnostic reasoning, ethical decision-making, and evidence-based practice (Papathanasiou, Kleisiaris, Fradelos, Kakou, & Kourkouta, 2014). It equips medical students to navigate ambiguity, synthesize complex patient data, and make sound clinical judgments. In today's rapidly evolving healthcare systems, the capacity to think critically is not just desirable but imperative (Berg, Philipp, & Taff, 2023; Khalifa, 2024).Given this

emphasis, medical educators continue to explore effective instructional strategies that best cultivate these skills. Among the contemporary approaches, Problem-Based Learning (PBL) and the Flipped Classroom (FC) model have drawn considerable attention for their potential to foster student engagement, independent thinking, and deeper learning.

Problem-Based Learning is an instructional method in which learners confront realistic clinical scenarios, identify knowledge gaps, and collaboratively investigate potential solutions. Rather than passively receiving information, students are encouraged to explore and construct knowledge actively (Nicholus, Muwonge, & Joseph, 2023). Numerous studies have reported the benefits of PBL in enhancing motivation, knowledge retention, and clinical reasoning (Gumartifa, Syahri, Siroj, Nurrahmi, & Yusof, 2023; Wijnia, Noordzij, Arends, Rikers, & Loyens, 2024). PBL also supports the development of metacognitive skills, which are critical to self-directed and critical thinking (Sutarto, Dwi Hastuti, Fuster-Guillen, Palacios Garay, Hernandez, & Namaziandost, 2022). However, despite these advantages, concerns remain about its scalability, dependence on well-trained facilitators, and the variability of student outcomes across different settings.

The Flipped Classroom model offers an alternative that redefines the role of classroom time. In this approach, foundational content is delivered outside the classroom—typically through video lectures or readings while face-to-face sessions focus on applying that knowledge through interactive tasks. This structure enables active learning, real-time feedback, and greater student autonomy (Choi, Moon, & Friedman, 2020; Hew & Lo, 2018). Recent meta-analyses indicate that flipped learning enhances learning outcomes, classroom interaction, and student satisfaction (Bredow, Roehling, Knorp, & Sweet, 2021). Furthermore, the flipped model aligns well with millennial learners' preferences for flexible, tech-mediated instruction (Cassar, Neal, & Schofield, 2022). Still, questions remain regarding its effectiveness in comparison to more established methods like PBL, particularly when the goal is to develop higher-order thinking rather than content mastery alone.

While both PBL and FC have demonstrated potential to foster critical thinking, direct comparisons between them remain limited. Many studies have evaluated each method in isolation, and few have systematically contrasted their effects on critical thinking within the same population. (Oliván-Blázquez et al., 2023; Zulhamdi, Rahmatan, Artika, Pada, & Huda, 2022). Moreover, existing research is often conducted in Western contexts, with limited exploration in resource-constrained settings or among diverse cultural groups (Aubeux et al., 2020). Furthermore, measurement tools and study designs vary significantly, making it difficult to draw generalizable conclusions. These gaps underscore the need for controlled comparative studies that evaluate the relative effectiveness of PBL and FC in enhancing critical thinking using standardized assessments and rigorous methodology. The rationale for this study stems from the urgency to identify and promote pedagogical approaches that effectively nurture critical thinking in medical students. Given the pivotal role that critical thinking plays in clinical decision-making and patient safety, it is essential to adopt teaching methods that move beyond rote learning and foster analytical, evaluative, and problem-solving capabilities. Comparing PBL and FC within the same educational context will help clarify which model offers more significant cognitive benefits, especially in terms of fostering critical reflection, adaptive reasoning, and lifelong learning habits.

This research is particularly significant for medical educators, curriculum designers, and academic policymakers. Findings from the study can inform decisions about instructional design, faculty training, and resource allocation. In settings where infrastructure or teaching staff may be limited, evidence-based guidance on the most effective model for promoting critical thinking could have far-reaching implications. Ultimately, this research contributes to improving medical education quality, thereby strengthening the clinical competence of future healthcare providers. The aim of the study is to compare the effectiveness of Problem-Based Learning and Flipped Classroom approaches in enhancing critical thinking among medical students.

The objectives include:

1. to assess the level of critical thinking among students exposed to PBL.
2. to assess the level of critical thinking among students taught through FC.
3. to compare the effectiveness of PBL and FC in developing critical thinking.
4. To explore students' perceptions of both teaching methods in terms of engagement, satisfaction, and perceived learning outcomes.

METHODOLOGY

This study adopted a quantitative, quasi-experimental research design to compare the effectiveness of Problem-Based Learning (PBL) and Flipped Classroom (FC) approaches in enhancing critical thinking among medical students. The research was conducted at a private medical college in Rawalpindi, Pakistan, known for integrating innovative teaching methodologies into its curriculum. The duration of the study spanned three months, from March 2025 to May 2025, coinciding with a routine academic semester, which allowed for the natural implementation of instructional interventions within the regular teaching timetable.

A total sample of 120 undergraduate medical students enrolled in their third year was selected through purposive sampling. These students were chosen because they had completed basic science modules and were beginning clinical subjects, thus requiring higher-order cognitive engagement. Sample size estimation was conducted using G*Power 3.1 software, employing an independent sample t-test (two-tailed) with an anticipated medium effect size (d = 0.50), an alpha level of 0.05, and a power of 0.95. The calculated minimum sample size was 102 participants, which was rounded up to 120 to compensate for potential attrition and ensure adequate statistical power. The students were divided equally into two groups: one receiving instruction through the PBL method and the other through the Flipped Classroom model.

The inclusion criteria required participants to be currently enrolled full-time in the MBBS program, have completed at least two years of medical education, and not have any prior formal training in critical thinking. Students with self-reported learning disabilities, those who had previously participated in PBL or flipped learning pilot projects, or those unwilling to provide informed consent were excluded from the study.

Critical thinking ability was measured using the California Critical Thinking Skills Test (CCTST), a widely validated instrument that evaluates core reasoning skills such as analysis, inference, evaluation, and deductive/inductive reasoning. The test comprises multiple-choice questions aligned with real-world problem scenarios and is suitable for use in higher education, particularly in health professions. In this study, the CCTST demonstrated strong internal reliability, with a Cronbach's alpha of 0.89. The instructional materials for both PBL and FC groups were developed based on the same clinical content to ensure content equivalence, but delivered through different pedagogical formats. For the PBL group, students were presented with clinical case scenarios that required guided group discussion, hypothesis generation, self-directed learning, and post-session debriefings. For the FC group, pre-recorded video lectures and digital resources were shared prior to class, with in-person sessions dedicated to case-based application exercises and instructor-led clarifications.

Data collection was conducted in two phases. In the first phase, participants in both groups completed the CCTST as a pre-test before the intervention. Over the next four weeks, both groups underwent their respective teaching interventions, delivered by trained faculty members who were oriented to ensure consistency in facilitation quality. Following the instructional period, a post-test using the same version of the CCTST was administered to assess changes in critical thinking ability. The response sheets were anonymized using coded identifiers to maintain confidentiality and minimize bias.

All quantitative data were entered into IBM SPSS version 25 for analysis. Descriptive statistics including mean scores and standard deviations were calculated to summarize participant demographics and baseline scores. Paired sample t-tests were applied within each group to examine pre- to post-intervention changes in critical thinking. Independent sample t-tests were used to compare post-test outcomes between the two instructional models. A significance threshold of $p < 0.05$ was set for all analyses. Assumptions of normality, homogeneity of variance, and independence of observations were checked and met prior to inferential testing. The results were interpreted to determine which instructional method yielded more significant gains in students' critical thinking development.

RESULTS

Table-1

Demographic Characteristics of Participants (n = 120)

Variable	Category	n (%)	Mean ± SD
Age (years)	–	–	22.26 ± 1.21
Gender	Male	38 (31.7%)	–

Variable	Category	n (%)	Mean ± SD
	Female	82 (68.3%)	–
Level of Education	MIT	120 (100.0%)	–
Accommodation	Day scholar	113 (94.2%)	–
	Hostel	7 (5.8%)	–
Resident of	Gilgit	7 (5.8%)	–
	Islamabad	34 (28.3%)	–
	Rawalpindi	79 (65.8%)	–
Part-time Job	No	89 (74.2%)	–
	Yes	31 (25.8%)	–
Socioeconomic Status	Low	58 (48.3%)	–
	Middle	27 (22.5%)	–
	Upper	35 (29.2%)	–

The demographic data presented in Table 1 reflects a sample of 120 participants, with a mean age of 22.26 years (SD = 1.21), indicating a relatively young cohort, consistent with typical medical student populations. The gender distribution shows a predominance of female students, comprising 68.3% of the sample, compared to 31.7% males. All participants were enrolled in the MIT program, indicating uniformity in educational level.

Most students (94.2%) were day scholars, suggesting limited hostel accommodation use. Geographically, most students were from Rawalpindi (65.8%), followed by Islamabad (28.3%) and Gilgit (5.8%). Regarding employment status, 74.2% reported no part-time job, while 25.8% worked part-time. In terms of socioeconomic background, nearly half (48.3%) of the students belonged to the low socioeconomic group, with fewer students in the middle (22.5%) and upper (29.2%) classes. These demographic insights provide context for understanding variations in academic engagement and learning outcomes across different instructional approaches.

Table-2

Mean Participation Scores for Problem-Based Learning and Flipped Classroom among medical Students (n=120)

Category	**Problem-Based Learning (Mean ± SD)**	**Flipped Classroom (Mean ± SD)**
Class Participation	7.52 ± 1.32	6.48 ± 1.76
Student Participation	7.36 ± 1.26	6.24 ± 1.62
Assignment Submission	6.72 ± 1.62	6.08 ± 1.68
Class Presentation	7.04 ± 1.18	5.84 ± 1.72

Table 2 presents the mean scores of student engagement indicators across two instructional models: Problem-Based Learning (PBL) and the Flipped Classroom (FC). Across all four measured categories—class participation, student participation, assignment submission, and class presentation—students exposed to PBL consistently scored higher than those in the flipped classroom setting. Specifically, PBL students had a class participation mean of 7.52 (SD = 1.32) compared to 6.48 (SD = 1.76) in the FC group. Similar trends were observed in student participation (7.36 vs. 6.24), assignment submission (6.72 vs. 6.08), and class presentation (7.04 vs. 5.84). These differences suggest that PBL may foster a more active and engaged learning environment, potentially due to its interactive and collaborative nature, which encourages students to take greater responsibility in classroom activities.

Table-3
Comparison of Pre- and Post-Test Scores for Critical Thinking Skills in Problem-Based Learning and Flipped Classroom (n=120)

Pair	Pre (Mean ± SD)	Post (Mean ± SD)	M.D	t	df	P
CBL	37.44 ± 6.86	49.84 ± 13.42	-6.20	-4.571	24	.000
IL	29.04 ± 7.40	36.72 ± 9.58	-3.84	-5.136	24	.000

The results in Table 3 compare pre- and post-test scores measuring critical thinking skills for both instructional models. In the Problem-Based Learning group, the mean pre-test score was 37.44 (SD = 6.86), which increased substantially to 49.84 (SD = 13.42) post-intervention. This reflects a mean difference of -6.20, which is statistically significant (t = -4.571, df = 24, p = .000), indicating a marked improvement in critical thinking following the PBL intervention. Similarly, students in the Interactive Lecture (IL) group showed a significant increase from a pre-test mean of 29.04 (SD = 7.40) to a post-test mean of 36.72 (SD = 9.58), with a mean difference of -3.84 (t = -5.136, df = 24, p = .000). While both instructional strategies led to significant gains in critical thinking, the PBL approach produced a higher post-test score and a larger mean difference, suggesting that it may be more effective in enhancing students' critical thinking abilities compared to traditional interactive lectures.

DISCUSSION

The aim of this study was to compare the effectiveness of Problem-Based Learning (PBL) and Flipped Classroom (FC) approaches in enhancing critical thinking among medical students. By assessing both pre- and post-intervention scores using the California Critical Thinking Skills Test (CCTST), and evaluating student engagement across different learning dimensions, the study sought to determine which instructional model was more effective in fostering critical thinking and promoting active learning behaviors in a cohort of third-year medical students.

The findings revealed that students taught through the PBL approach consistently outperformed those in the Flipped Classroom model across all measured domains of participation and engagement, including class participation, student participation, assignment submission, and class presentations. This suggests that the collaborative and inquiry-driven nature of PBL may contribute to higher levels of cognitive and behavioral engagement. The post-test critical thinking scores also indicated a greater improvement in the PBL group (mean post-test = 49.84) compared to the FC group (mean post-test = 36.72), with both groups showing statistically significant gains. These results support the assertion that while both methods have pedagogical value, PBL may be more effective in promoting higher-order thinking and critical reasoning skills. These findings align closely with existing literature, which has consistently highlighted the cognitive benefits of Problem-Based Learning in medical education. For instance, a recent study by Manuaba and Wu (2020), found that PBL significantly improved analytical reasoning and problem-solving abilities among clinical students in comparison to traditional lectures (Manuaba, & Wu, 2022). Similarly, Rivas et al., (2022), emphasized that PBL environments support the development of metacognitive regulation, allowing learners to reflect, evaluate, and adjust their thinking processes in response to complex clinical problems (Rivas, Saiz, & Ossa, 2022). The current study's findings also resonate by Setiadi, (2021), who in their systematic review noted that PBL promotes deeper learning by encouraging students to take ownership of their learning processes (Setiadi, 2021).

On the other hand, the Flipped Classroom model demonstrated notable, albeit smaller, gains in critical thinking, suggesting that it too can serve as a valuable instructional strategy when properly implemented. Several recent meta-analyses and empirical studies support this view. For example, Li et al., (2023), conducted a meta-analysis of flipped learning in health professions and reported moderate improvements in critical thinking, particularly when classroom application activities were tightly aligned with learning outcomes (Li, Wang, Weng, & Zhibao, 2023). Similarly study conducted by Shi et al., (2025), found that the FC model improved engagement and student satisfaction in medical students, though gains in critical thinking were modest compared to active problem-solving methods (Shi et al., 2025).

Despite its effectiveness, the FC model may not inherently demand the same level of cognitive autonomy and iterative reflection that PBL fosters. As Paul and colleagues (2023), suggest, the depth of student engagement in FC depends heavily on the quality of pre-class materials and the design of in-class

application tasks. Without rich opportunities for debate, inquiry, and feedback, FC may fall short in cultivating the evaluative and inferential dimensions of critical thinking (Paul et al., 2023).

Additionally, the context of the study conducted in a resource-limited setting in Pakistan underscores the practical importance of identifying instructional models that are not only pedagogically sound but also feasible to implement (Hernando-Garijo, Hortigüela-Alcalá, Sánchez-Miguel, & González-Víllora, 2021). Given the PBL model's dependence on skilled facilitators and smaller group sizes, scalability remains a concern. However, the observed cognitive benefits may justify investments in faculty development and infrastructure to support its broader adoption. Conversely, the FC model's flexibility and reduced faculty burden may make it a more attractive option in contexts where faculty expertise or instructional time is limited, even if its impact on critical thinking is somewhat lower.

CONCLUSION

This study aimed to compare the effectiveness of Problem-Based Learning (PBL) and the Flipped Classroom (FC) models in enhancing critical thinking among medical students. The findings provide clear evidence that while both instructional strategies significantly improve students' critical thinking abilities, PBL offers superior outcomes in terms of both cognitive gains and learner engagement. Students in the PBL group demonstrated higher post-test scores on the California Critical Thinking Skills Test (CCTST) and reported greater involvement in class participation, assignment completion, and presentations compared to those in the FC group. The results affirm that active, inquiry-driven instructional formats like PBL are particularly effective in promoting higher-order thinking, reflective reasoning, and deeper learning. Although the Flipped Classroom also contributed positively to critical thinking development, its impact was relatively modest, indicating that the success of such models depends heavily on the quality of pre-class materials and the design of in-class learning activities. Given the increasing emphasis on critical thinking in clinical education, this study underscores the importance of selecting pedagogical models that go beyond content delivery and foster analytical and evaluative skills essential for medical practice. Medical educators and curriculum designers should consider integrating PBL more widely, especially in settings where critical thinking development is a curricular priority. Additionally, adaptations and hybrid approaches that combine the strengths of both PBL and FC could be explored to maximize learning outcomes while ensuring scalability and flexibility in diverse educational contexts.

LIMMITATIONS AND RECOMMENDATION OF THE STUDY

While the findings of this study offer valuable insights into the comparative effectiveness of Problem-Based Learning (PBL) and Flipped Classroom (FC) models in enhancing critical thinking among medical students, several limitations should be acknowledged. First, the study employed a quasi-experimental design with non-randomized group allocation, which may introduce selection bias and limit the ability to establish definitive causal relationships. Second, the sample was drawn from a single private medical institution in Rawalpindi, Pakistan, which may affect the generalizability of the results to other educational settings, particularly public-sector institutions or those in different cultural or geographic regions. Third, although the California Critical Thinking Skills Test (CCTST) is a validated tool, it may not fully capture the complexity of clinical reasoning as it occurs in real-life medical practice. The reliance on self-reported participation measures, without direct observational data, may also be subject to social desirability bias. Furthermore, the relatively short intervention period of four weeks might not reflect the long-term impact of either instructional method on sustained critical thinking development.

Based on these limitations, several recommendations are proposed for future research and educational practice. First, future studies should consider using randomized controlled trial designs and larger, multi-center samples to enhance the validity and generalizability of findings. Including a more diverse group of participants from various academic years, institutions, and socioeconomic backgrounds would provide a broader perspective on instructional effectiveness. Longitudinal studies are also needed to examine the durability of critical thinking gains over time and their transferability to clinical settings. Additionally, mixed-methods research incorporating qualitative feedback from students and faculty could offer deeper insights into the perceived strengths, challenges, and contextual appropriateness of each teaching model. Educators are encouraged to invest in faculty development programs to ensure consistent and high-quality implementation of active learning strategies. Finally, integrating hybrid models that

blend the case-driven depth of PBL with the flexibility of FC may offer a balanced and scalable approach for enhancing critical thinking across various medical education contexts.

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