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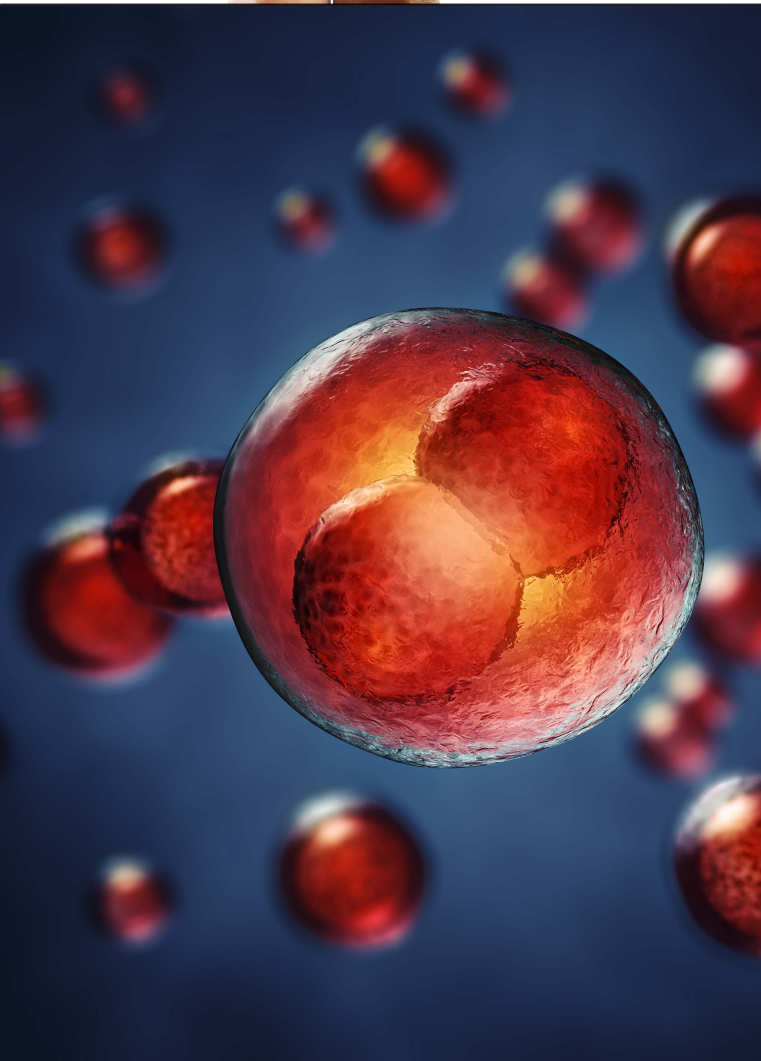
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A Comparative Study of Flipped Classroom Teaching Method vs Traditional Classroom Teaching Method in Undergraduate Medical Students

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Abstract:

Background: The flipped classroom (FC) model reverses the traditional lecture and homework roles, and helps promote active engagement, develop higher-order cognitive skills necessary for physicians. This interventional cross-sectional study compared the effectiveness of the FC with traditional lecture-based teaching among undergraduate medical students in Pakistan.

Methods: A cross-sectional interventional study was conducted with 70 final-year MBBS students at a private medical college in Lahore. Participants were divided into two groups: FC and Traditional. The FC group received study material via WhatsApp 24 hours pre-class, while the traditional group took lectures in class. Assessment included pre-tests, post-tests, and pre-validated feedback questionnaires for students and faculty. Data was analyzed using SPSS v.25, employing appropriate statistical tests.

Results: The FC group consistently achieved higher mean scores in both pre-tests and post-tests compared to the traditional group. Independent t-tests demonstrated statistically significant difference in scores of two groups; 2x2 ANOVA showed that where improvement in scores was seen in FC group, it was not always statistically significant. 82.9% of students agreed that FC created an interactive environment. While 63.3% of faculty strongly agreed that FC increased student learning, while half (46.7%) noted it was more resource intensive.

Conclusion: The FC model significantly enhances academic performance and student engagement compared to traditional methods.

Key Words:

Flipped Classroom; Medical Education; Academic Performance

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Introduction

Our current teaching methodologies primarily rely on lectures and self-study; however, modern technology has revolutionized student learning. Identifying teaching and learning needs is the first step to making students more capable learners.¹ Teacher-centered education models remain widespread in many developing countries, slowing the transition to modern learning methods. In this unidirectional knowledge transfer, the instructor provides information while employing rote-learning methods rather than the required critical engagement.^(2,3) Student-centered approaches have transformed teaching methods worldwide in higher education, thereby improving academic outcomes.⁴ While designing the undergraduate medical education curriculum, learning goals should aim to make students proactive learners and encourage evidence-based problem-solving.⁵ The use of traditional lectures as the primary learning tool limits the development of higher-order cognitive skills.⁶ To drive better results, research suggests

that adopting flexible learning models like flipped classrooms and the utilization of modern digital resources can be highly effective.⁷

Flipped classrooms (FC) use a blend of teaching methodologies to optimize the learning environment.⁸ In practice, in the FC approach, learning material is provided before the actual class, freeing up time for active learning during class. Variation in content delivery for FCs is observed across studies, making it a more flexible approach for adoption in medical education.⁹ In the FC model, instructors reverse the traditional order of schoolwork and homework by providing pre-recorded lectures or other study material before the actual class. Students review these resources before class and can, in turn, engage in more fruitful discussions during class.^{10,11} This technique aligns with Bloom's taxonomy, a comprehensive curriculum framework that describes how understanding of foundational knowledge is followed by higher-order analysis and evaluation.¹²

A study conducted in Thailand explored attitudes of students towards active learning in health education and found that most students preferred active learning techniques, and these benefit their cognition, self-efficacy, and attention span while developing essential 21st-century skills in them.¹³

The FC method offers numerous advantages, including personalized learning pace, enhanced concept-building through peer interaction, reduced anxiety, and increased student confidence.¹⁴ There is a lack of research on the benefits of flipped classrooms for raising medical students' academic achievement; thus, comparisons with standard classroom settings and lectures are necessary. Our study compares the performance of medical students when taught using traditional methods versus the FC approach.

Materials and Methods

A cross-sectional interventional study was conducted at a private medical college in Lahore, with IRB approval from the Ethical Review Board. The total sample size was 70 MBBS final-year students, and convenience sampling was used. We divided the students into two groups: traditional and flipped, each with 35 students. Informed consent was taken from all participants. Any student who did not consent to participate was excluded.

We carried out the intervention for over a month, divided into four sessions. To increase the study's validity, four tests were administered during four separate lectures in the final-year Internal Medicine course on the following topics: malaria, dengue, Enteric Fever, and tuberculosis. The flipped group received and reviewed the study materials the day before class, whereas the traditional group received none. Pretests were administered to both groups via Google Forms, and responses were closed after the class began. After the lecture, post-tests were administered in the same manner as pretests, and the form was closed 15 minutes after the lecture. Both pretests and post-tests for different groups

were administered on separate Google Forms and WhatsApp groups to prevent participant mixing while ensuring confidentiality. Pre-validated feedback questionnaires were also distributed to faculty and students. No scores were revealed to the participants.

The data were analyzed using SPSS version 25, with the relevant statistical tests including the Shapiro-Wilk test to assess normality and independent-samples t-tests to compare pre- and post-test scores between groups. To provide a more robust analysis of the intervention's efficacy, we conducted a 2x2 Mixed ANOVA to account for the study's repeated-measures design, allowing evaluation of within-subject knowledge acquisition over time.

Results

The mean and standard deviation of scores for both groups were calculated for all four tests (shown in Table 1). The data for scores were normally distributed. Overall, the mean scores for both the pre-test and post-test were higher for students in the flipped class group, e.g., 3.11 vs 2.1. Independent t-tests were used to analyze the difference between pre-test and post-test scores across two groups. For most tests, the p-value was less than 0.001, indicating a statistically significant difference in score between the two groups. (Table 1)

This was followed by a 2x2 ANOVA to control baseline pre-test disparities and calculate the interaction effect between time and teaching modality, a more accurate measure of the FC's true impact on learning. This evaluated the effects of time (pre-test vs. post-test) and teaching method (flipped vs. traditional) on student scores. A statistically significant main effect of time was observed across all four tests ($p \leq 0.001$), indicating overall improvement in knowledge regardless of the teaching method. For Tests 1, 2, and 3, there was no statistically significant interaction between time and teaching method ($p > 0.05$). However, Test 4 revealed a significant interaction effect, $F(1, 68) = 8.04$, $p = 0.006$, partial eta squared = 0.106 (Table

Flipped or Traditional		Pre-test 1 score	Pre-test 2 score	Pre-test 3 score	Pre-test 4 score	Post-test 1 score	Post-test 2 score	Post-test 3 score	Post-test 4 score
Flipped	Mean±SD	3.11±0.53	2.69±0.87	3.03±0.66	2.63±0.65	3.71±0.46	3.63±0.55	3.60±0.55	3.40±0.50
Traditional	Mean±SD	2.114±1.08	1.88±1.02	2.00±0.01	2.57±0.70	2.77±0.94	2.857±0.85	2.314±1.13	2.714±0.83
Independent T-test	P-value	<0.001	0.001	<0.001	0.723	<0.001	<0.001	<0.001	<0.001

Table 1: Comparison of mean scores between flipped classroom and traditional method

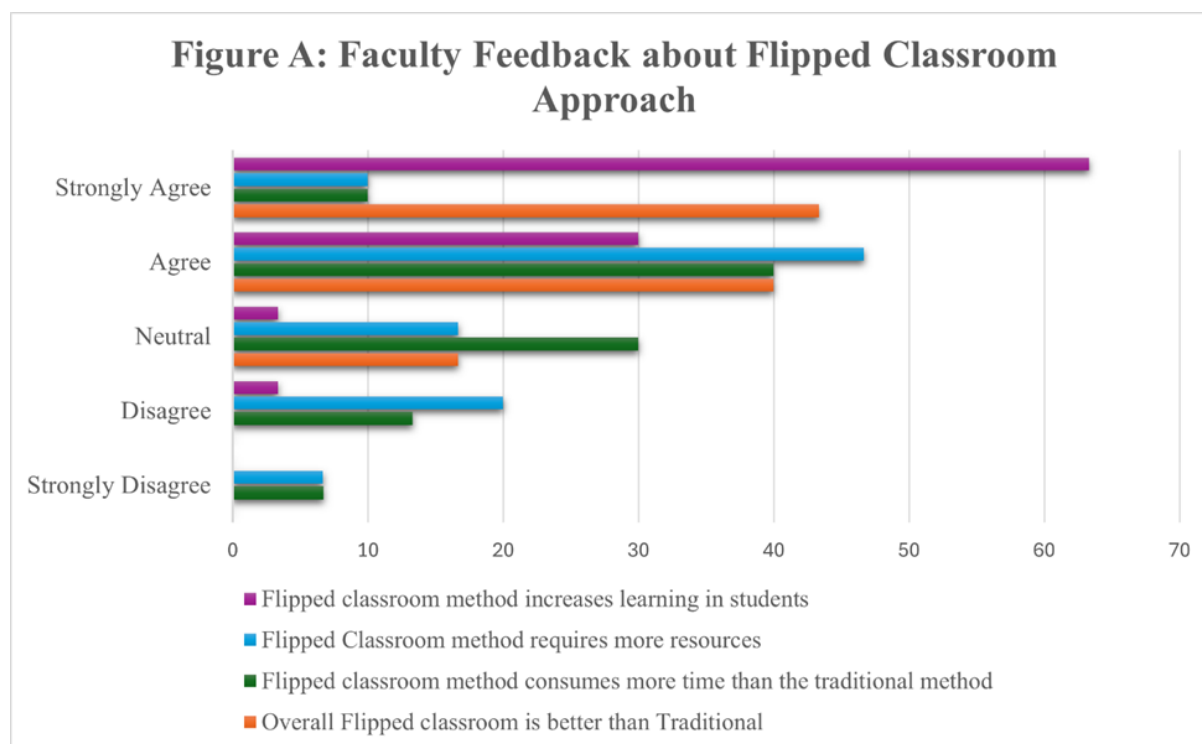


Figure I: Student Feedback on the Flipped Classroom Experience.

2). This demonstrates that, for this specific module, students in the flipped classroom achieved a significantly greater improvement from pre-test to post-test than those in the traditional classroom.

Student and faculty input indicated a preference for a flipped classroom approach. A total of 30 faculty members responded. Over ninety percent of the faculty agreed that the FC method increases learning in students, with only one faculty member who completely disagreed. More than seventy percent said that flipped classroom required more resources. Half of all faculty members found the FC method more resource-intensive (Figure 1)

Student feedback showed overall positive perceptions of the flipped classroom method. Over seventy percent agreed that it created interest in the topic. Most students agreed that the flipped classroom method improved learning, allowed ample time allocation, and provided an interactive learning environment, with very few students in disagreement. (Figure 2).

Discussion

The present study compared the flipped classroom teaching method with the traditional lecture-based approach among final-year medical students. While both modalities significantly improved overall knowledge acquisition ($p < 0.001$ across all modules), FCs can lead to a significantly higher rate of academic score improvement. Despite equivalent

baseline knowledge, the FC group demonstrated a statistically significant interaction effect ($p = 0.006$), indicating faster, more robust learning than the traditional cohort. These findings are consistent with previous studies that also showed elevated academic performance among students taught using FCs.

Mean post-test scores were also higher among the FC cohort, indicating better learning. This finding was consistent with previous studies, which also showed that post-tests were significantly higher for students taught using the flipped classroom method.⁽¹⁵⁻¹⁸⁾ Another study, however, conducted at Al-Neelain University in Sudan, found no significant differences between the pre-test and post-test results, which shows that variation may exist due to differences in institutional culture and student readiness.¹⁹

Feedback from both students and faculty was also strongly in favor of the flipped method. Students reported greater interest, improved understanding, and enhanced learning compared with traditional lectures, as seen in other studies conducted in Sudan and the USA.^(19,20) The student feedback, as shown in Figure B, indicates that the FC method created a more interactive environment (82.9% agreement) and generated greater interest in the taught topic (74.3% agreement). The shift in post-test scores in the flipped classroom group was likely due to students' active in-class participation, which

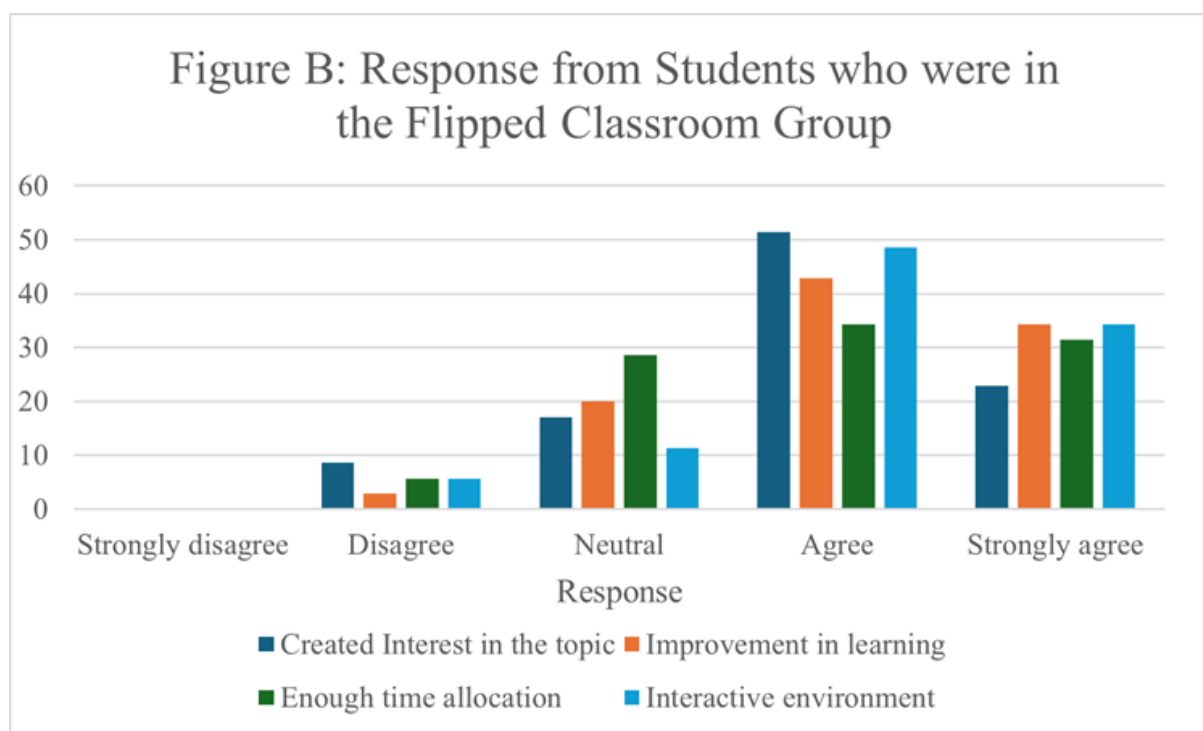


Figure 2: Student Feedback on the Flipped Classroom Experience.

Test Module	Effect	F(1,68)	p-value	Partial Eta Squared (η^2)
Test I	Main Effect (Time)	25.32	< 0.001	0.271
	Interaction (Time X times) Method)	0.05	0.82	0.001
Test I	Main Effect (Time)	51.39	< 0.001	0.43
	Interaction (Time X times) Method)	0.01	0.915	< 0.001
Test I	Main Effect (Time)	11.95	0.001	0.149
	Interaction (Time X times) Method)	1.01	0.319	0.015
Test I	Main Effect (Time)	17.02	< 0.001	0.2
	Interaction (Time X times) Method)	8.04	0.006	0.106

Table 2: Summary of 2x2 Mixed ANOVA Results Across Test Modules.

led to better retention of the concepts, a benefit that medical education can significantly leverage. Another study at AKU, Karachi, found that many students found the FC approach more effective and preferred it over traditional lectures. They reported that their queries and misunderstandings were better handled, and they retained more concepts.¹⁷

While faculty members were satisfied with the

overall effectiveness of the flipped classroom method, many found it resource- and time-intensive, limiting its feasibility in institutions with limited financial support. The faculty's opinion was consistent with another study conducted in India, in which sixty percent found it resource-intensive, and eighty percent believed it uses more time than the traditional method of teaching.²¹ Our student feedback, as depicted in Figure B, suggests that

ample time was allocated for the topic, which indicates that the faculty's time investment in improving teaching methods can prove beneficial for students' overall understanding.

Even though the effect of the teaching method was statistically insignificant in 3 of the tests as per 2x2 ANOVA, it is important to consider that efficacy may vary from subject to subject, and the method may not always be effective when used alone. Studies have used flipped classrooms with other modern methods of learning, such as using virtual reality, to help improve the understanding of students. One such study found that the use of a flipped classroom combined with virtual microscopy resulted in significantly improved assessment scores.²² Our study, however, focused mainly on the flipped classroom intervention using basic digital resources such as WhatsApp to study the generalizability of the concept in low-resource settings, such as in most medical education institutions of Pakistan and other South Asian and African countries.

Future research can compare effectiveness in pre-clinical and clinical settings to determine where its application is more viable. The use of advanced Learning management software could distribute resources and prevent contamination of the intervention. Studies can also assess long-term retention of the subject material by administering a follow-up post-test within 6 months.

Conclusion

Overall, the pre- and post-test scores were higher in the flipped classroom group when compared to the traditional learning group, even though the results were not always statistically significant. The students were more satisfied with their learning through the flipped classroom approach. The faculty members found the method to be resource-intensive, but they were positive that it improves learning in students. Although it may pose logistical challenges for resource-constrained institutions, it can still be implemented strategically to enhance the quality of learning for medical students, who will be the face of future healthcare.

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