

## Medical Education

# Flipped classroom-based teaching as a tool for reinforcement of learning among undergraduates - An analytical study

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## ABSTRACT

**Objectives:** The integration of theory and practice is a cornerstone of the competency-based medical education (CBME) curriculum, necessitating innovative teaching-learning methods to bridge the gap between knowledge acquisition and its practical application. This analytical study aimed to evaluate the effectiveness of the flipped classroom approach in reinforcing pharmacology concepts among second-professional MBBS students at ESIC Medical College, Joka, India.

**Materials and Methods:** A total of 101 Phase 2 MBBS students were randomly divided into two groups: One receiving traditional tutorials and the other participating in flipped classroom sessions. Topics covered included drugs used in peptic ulcer disease and antiemetic drugs. A validated questionnaire, comprising multiple-choice and short-answer questions, was administered before and after the intervention to assess knowledge retention.

**Results:** Baseline pre-test scores showed no significant differences between the groups. However, post-test analysis revealed a statistically significant improvement in the flipped classroom group ( $P = 0.02$ ), indicating enhanced learning outcomes compared to the traditional tutorial group.

**Conclusion:** The flipped classroom method demonstrated superior effectiveness in reinforcing pharmacological concepts among undergraduate medical students, as evidenced by statistically significant post-intervention improvements. These findings suggest that flipped classroom-based teaching can be a valuable addition to the CBME framework, promoting deeper understanding and application of theoretical knowledge in clinical contexts.

**Keyword:** Flipped classroom, Medical education, Pharmacology, Teaching learning method

## INTRODUCTION

Integrating theoretical knowledge with clinical practice has long been recognised as a fundamental objective in medical education. This integration has become increasingly critical in the context of recent curricular reforms in the undergraduate MBBS program, which emphasise competency-based learning. With the exponential growth in biomedical knowledge over the past two decades, medical students are now expected not only to assimilate a vast volume of information but also to apply it meaningfully in clinical scenarios. Consequently, educational strategies that bridge the

gap between knowledge acquisition and practical application have garnered considerable attention.

Despite the extensive use of traditional didactic lectures in medical education, a growing body of evidence suggests that such methods often lead to passive learning. A meta-analysis conducted by Singh and Kharb concluded that lectures alone do not adequately engage students in the learning process and recommended incorporating interactive, student-centred strategies to promote active learning.<sup>[1]</sup> Saulnier has similarly emphasised the importance of shifting instructional design towards learner-centred models to foster metacognitive skills, which are essential for developing independent and self-directed learners.<sup>[2]</sup>

Among various active learning strategies, concept mapping has been shown to enhance understanding and retention of complex information. For instance, Dinarvand and Vaisi-Raygani reported that self-constructed concept maps by MBBS students significantly improved their comprehension of assigned competencies.<sup>[3]</sup> Reinforcing this finding, a prior study conducted in the department of biochemistry at our institution observed notable knowledge gains among low-performing students who were taught using concept mapping techniques.<sup>[4]</sup>

However, one pedagogical approach that remains underutilised in the Indian medical education context is the flipped classroom model. A study by Bergmann and Sams (2012) found that flipping the classroom increased student engagement and achievement.<sup>[5]</sup> While this method has gained popularity globally as an effective active learning strategy, it has not been widely adopted among Indian medical educators, particularly as a means of reinforcing core clinical concepts. The flipped classroom technique reverses the traditional learning environment by delivering instructional content outside of the classroom through pre-recorded lectures or reading assignments, and dedicating in-class time to discussion, problem-solving and application of knowledge.

## Aim and objectives

### Aim

1. The primary aim of this study was to assess the effectiveness of the flipped classroom approach as a reinforcement method for teaching selected topics in pharmacology to undergraduate students.
2. We also attempted to gather feedback from students regarding their experiences with the flipped classroom approach, to make necessary adaptations and improvements to this teaching method.

### Specific objectives

1. The primary objective was to compare the effectiveness of didactic lectures along with the flipped classroom technique as a reinforcement tool versus didactic lectures along with the conventional tutorial method (small group teaching). Effectiveness was assessed by comparison of performances and understanding between students who received flipped classroom-based instructions versus those subjected to a traditional lecture-based approach.
2. The secondary objective was to explore students' perceptions towards this novel method of teaching using appropriate questionnaires.

## MATERIALS AND METHODS

### Study design and duration

This was an open-label parallel group randomised controlled interventional study design conducted at the Department of Pharmacology, ESI, Post Graduate Institute of Medical Sciences and Research (PGIMSR), ESIC Medical College, Joka, Kolkata, after obtaining approval from the Institutional Ethics Committee.

### Study population, sampling technique and sample size

The study population consisted of the available and consenting 2<sup>nd</sup> phase MBBS students at ESI, PGIMSR, ESIC Medical College and Hospital, Joka, Kolkata. All consecutive 2<sup>nd</sup> Prof MBBS students were approached. Complete enumeration, which is a subtype of purposive sampling, was used to select samples. Those satisfying the inclusion criteria who willingly participated and gave written informed consent were selected and were subsequently subjected to stratified randomisation to the two teaching groups. To include both low-scoring and high-scoring students in either group to avoid potential bias, stratification into low- and high-scoring groups was done (based on 5<sup>th</sup> semester marks in the current phase) before randomisation. The study was conducted on a final sample size of 101 students.

### Inclusion and exclusion criteria

All 2<sup>nd</sup> prof MBBS students who were willing to participate and gave written informed consent were included.

### Study parameters

Student performance was assessed using two pre-validated sets of questionnaires consisting of multiple-choice questions and short answer questions related to drugs used in peptic ulcer and antiemetics. The questionnaires were administered

at 3 time points using Google Forms: (i) Baseline (before any teaching), (ii) Pre-test (after didactic lecture) and (iii) Post-test (after reinforcement by either flipped classroom or tutorial).

Two different but equally validated sets of question papers were used across these 3 time points to minimise recall bias. The sets were rotated and counterbalanced between participants. Performance scores were calculated out of 20, and Cronbach's alpha was used to assess internal consistency.

Perception and satisfaction regarding the flipped classroom technique were evaluated using a structured feedback form filled out by students in the flipped classroom group.

To ensure ethical equity, if one teaching method was found to significantly outperform the other, the superior method was reapplied to the initially unexposed group.

### Study technique

The methodology included stratified randomisation followed by implementation of the respective interventions. The flipped classroom group received pre-class reading materials and video lectures. In-class sessions focused on case discussions, peer interaction and application-based problem solving, facilitated by a moderator. The tutorial group received conventional instructor-led teaching. The overall scheme of conduction and analysis is shown in Figure 1.

### Data analysis and result presentation plan

Data were entered and analysed using R version 3.3.3 R Studio version 1.0.136 (R Foundation) statistical software (Language). The responses to the questionnaire were scored numerically on a total score of 20, and statistical analysis was done from those numerical parameters. Between-group comparisons were done in addition to descriptive statistical analysis.  $P < 0.05$  was considered statistically significant. Test scores were expressed as Mean  $\pm$  Standard Deviation and Median  $\pm$  Interquartile range. The same was expressed graphically by a Box and Whiskers plot. A Wilcoxon rank sum test was used to determine any difference between the two groups.

## RESULTS

The mean test scores before exposing the students to any method (baseline scores) as described in Table 1, were found to be uniform with a non-significant  $P = 0.46$ , suggesting that both the groups were comparable [Table 1 and Figure 2a]. The pre-test score values in both the Flipped Classroom group (group 1) and the Tutorial group (group 2) were 15.8 and 16.7, respectively with a  $P = 0.44$  indicating that the exposure of both the groups to the didactic lecture teaching was more or less uniform [Table 1 and Figure 2b]. However, after the intervention, the post-test scores were found to vary considerably between groups. The mean score obtained by the flipped group (group 1) was 16.7 with a standard deviation of 1.8, and for the tutorial group (group 2) was 15.7 with a standard deviation of 1.9. A  $P = 0.02$  indicated that the difference in scores was statistically significant, suggesting that the flipped group method might be superior compared to the tutorial group method for the selected topic [Table 1 and Figure 2c]. Since the data was not normal, the Wilcoxon rank-sum test method was used to obtain the  $P$ -values.

The perception questionnaire was administered to those exposed to the flipped classroom technique scores were obtained from such students as described in Figure 3. To summarise the results of these scores, most of the answers related to open-ended questionnaires described this novel method as a very effective teaching-learning tool, exploring one's understanding and knowledge. Students found this method to be more productive with greater opportunity for interactions. There were no major negative comments from students related to this novel method.

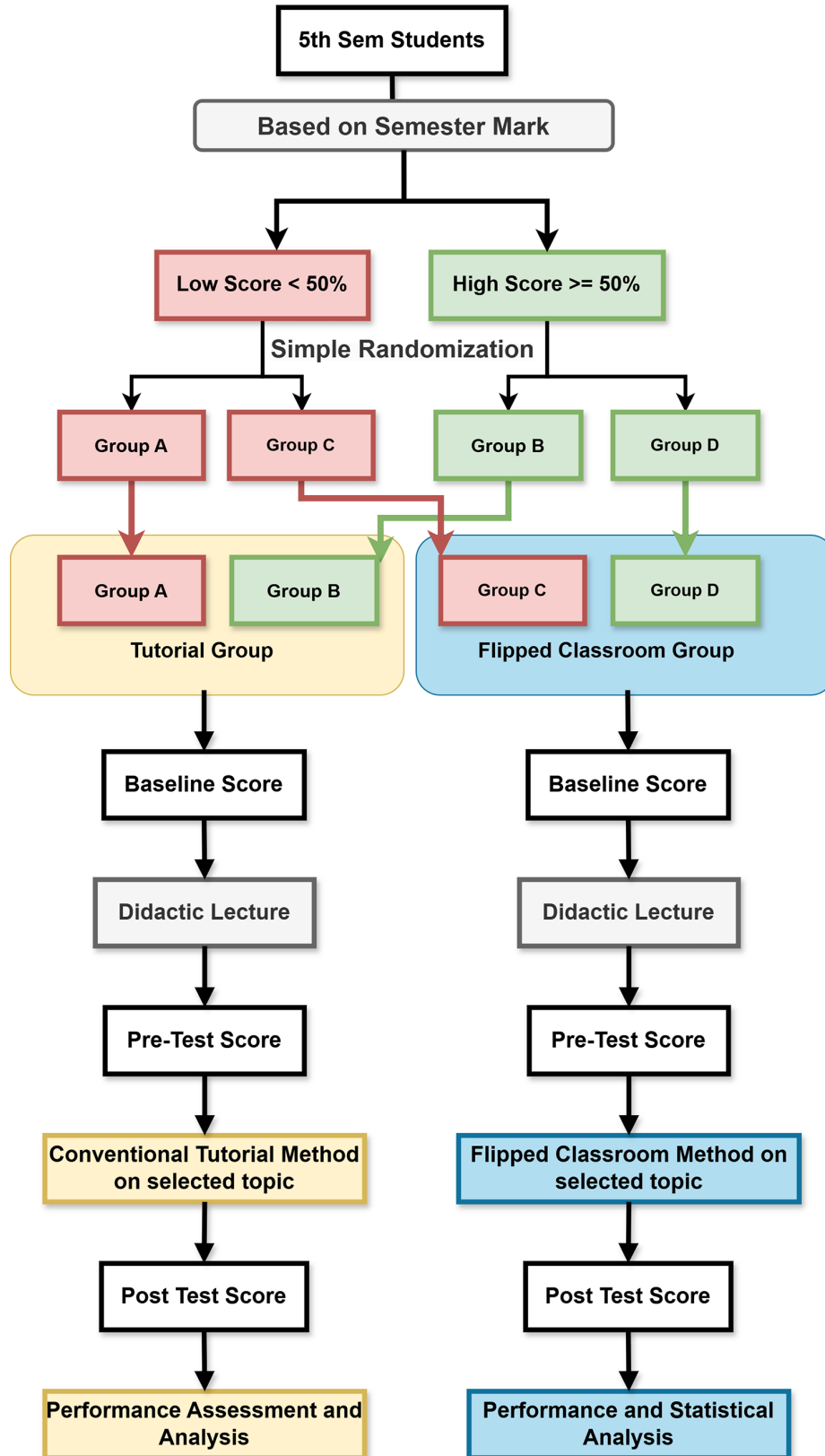
## DISCUSSION

In this pilot study conducted among phase 2 MBBS students using a few selected competencies in the subject of pharmacology, a novel teaching-learning tool was evaluated versus a standard conventional tool by assessing teaching outcomes in terms of student participation and performance. Students were randomised into two groups stratified by performance scores; both groups were exposed to a didactic lecture on the topics, and subsequently, a reinforcement session was planned for each student. One group was exposed

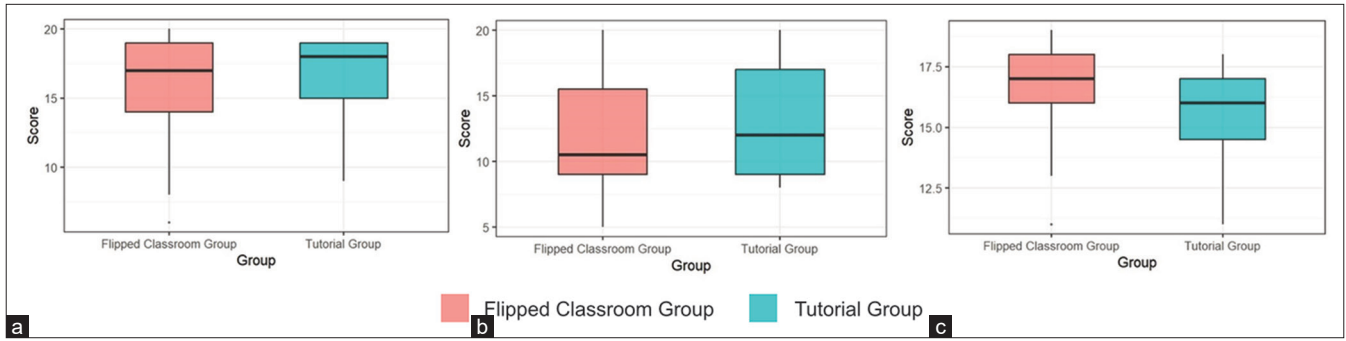
**Table 1:** Comparison of mean performance scores between the flipped group (Group I) versus the tutorial group (Group II).

Scores at different levels	n	Mean $\pm$ SD		Median score		P-value*
		Group I	Group II	Group I	Group II	
Baseline score	58	12.1 $\pm$ 4.5	13.1 $\pm$ 4.2	10.5	12	0.46
Pre-test score	94	15.8 $\pm$ 3.7	16.7 $\pm$ 2.68	17	18	0.44
Post-test score	66	16.7 $\pm$ 1.8	15.7 $\pm$ 1.9	17	16	0.02

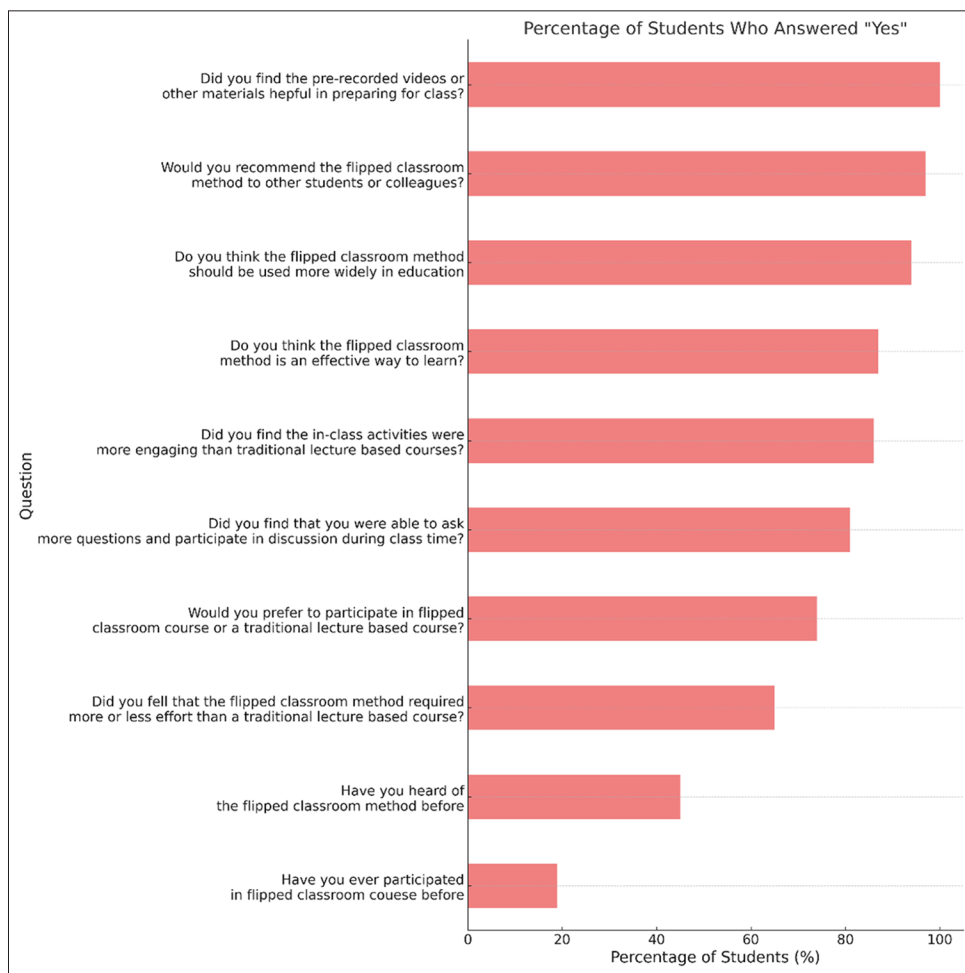
\*P-value based on the Wilcoxon rank sum test. SD: Standard deviation



**Figure 1:** Study flow diagram. Stratified randomization was done to ensure both the groups contains students of similar academic profile.



**Figure 2:** Box and whisker plots comparing test scores between Flipped Classroom Group (pink) and Tutorial Group (turquoise) at 3-time points: (a) Baseline scores before didactic lecture and (b) Pre-test scores after didactic lecture but before intervention showing comparable performance between groups. (c) Post-test scores after intervention showing higher performance in the Flipped Classroom Group. The boxes represent interquartile ranges with median lines and whiskers indicate minimum and maximum values excluding outliers.



**Figure 3:** Perception of the students regarding Flipped class room method as a novel approach to teaching leaning method.

to the conventional tutorial method, and the other group was exposed to a flipped classroom teaching method. Performance was assessed thrice, first at baseline, next after the didactic session, and finally after the reinforcement session.

The mean scores of student performances between the two groups at baseline before any intervention were 15.8 and 16.7, with a  $P = 0.46$ . This non-significant difference in mean pre-test scores suggested that the two groups were comparable

before any teaching method was implemented. Subsequently, the pre-test assessment scores between the two groups following exposure to the traditional didactic lecture method yielded a  $P = 0.44$ , reinforcing the notion that the group performances remained uniform. However, when comparing post-test scores, a statistically significant difference emerged ( $P = 0.02$ ) between the flipped and tutorial groups, with the flipped group outperforming the tutorial group. The Wilcoxon Rank-sum test was employed due to the non-normal distribution of the data. A questionnaire-based evaluation was finally performed among students exposed to the flipped classroom technique to evaluate their perception regarding this novel teaching method. Inputs received were mostly positive and optimistic. Students considered this method to be effective with potential for better understanding and retention.

The subsequent discussion delves into the broader context of these findings by referencing relevant literature on the flipped classroom method. The popularity of this pedagogical approach has surged in recent years, driven by its potential to elevate student engagement and learning outcomes. Hew and Lo's (2018) meta-analysis, encompassing diverse disciplines, revealed significant improvements in student achievement when using the flipped classroom method compared to traditional lecture-based courses.<sup>[6]</sup> The positive impact extended beyond grades, influencing student attitudes toward learning and fostering increased engagement.

However, the literature is not without conflicting findings. Kay and Le Sage's (2009) study reported no significant differences in student achievement between a flipped classroom and a traditional lecture-based course, suggesting that the effectiveness of the flipped method may vary across contexts.<sup>[7]</sup> Similar inconsistencies were found in Lage *et al.*'s (2000) study, where although students in a flipped classroom reported higher engagement, there was no significant difference in achievement compared to a traditional course.<sup>[8]</sup>

In contrast, Pierce and Fox's (2012) study demonstrated higher engagement levels and better grades for students in a flipped classroom compared to those in a traditional lecture-based course.<sup>[9]</sup> Strayer (2012) investigation into a college-level physics course further supported the benefits of the flipped classroom, revealing improvements in both conceptual understanding and problem-solving skills.<sup>[10]</sup>

The study encountered several notable limitations that warrant consideration. First, being a single-centre study with a relatively small sample size limits the generalisability of findings to broader student populations. The scope was restricted to only two pharmacology topics, potentially not reflecting the method's effectiveness across diverse medical concepts. The lack of long-term follow-up assessment made it impossible to evaluate knowledge retention over time. In addition, significant participant dropout during the post-test

phase could have introduced selection bias. The study also didn't account for students' prior familiarity with technology or their learning preferences, which might have influenced their engagement with the flipped classroom method.

Although our study yielded optimistic results in favour of the flipped classroom technique, the synthesis of a summary of findings as evidenced by a thorough literature review underscores the complexity of evaluating the flipped classroom method's effectiveness. The diverse outcomes may be attributed to variations in implementation, student populations and subject matter. While some studies highlight its positive impact on engagement and achievement, others present conflicting results, necessitating a nuanced interpretation.

## CONCLUSION

The literature review corroborates the potential efficacy of the flipped classroom method in enhancing student engagement and learning outcomes. In our study, the flipped classroom group outperformed the tutorial group. However, the conflicting findings underscore the need for further larger studies involving diverse medical competency topics across diverse student populations to duly assess the strengths and weaknesses of this novel teaching-learning tool. All the more, this emphasises the need for a subtle understanding of the factors influencing its effectiveness. As educational practices continue to evolve, further research is imperative to elucidate the nuanced interplay between teaching methods, contextual factors and student outcomes in diverse educational settings.

**Ethical approval:** The research/study was approved by the Institutional Review Board at ESI-PGIMS and ESIC Medical College, Joka, approval number ESIC/156/IEC (JOKA)/2023, dated 29th August 2023.

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