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Original Research Article

Flipped classroom paradigm facilitates the learning of physiology in medical students: a prospective study

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ABSTRACT

Background: Flipped classroom teaching promotes active learning by shifting basic content outside the classroom and using class time for discussion and application. This study assessed its effect on performance, retention and student perception in physiology.
Methods: This prospective crossover study was conducted among first-year MBBS students from August 2024 to July 2025 in KGMU, Lucknow. Students were randomly assigned to Groups E and F, with 30 participants in each group. Initially, Group E received traditional teaching and Group F received flipped classroom teaching, followed by immediate and two-day retention tests. After a 15-day washout period, the teaching methods were crossed over and assessments repeated. Flipped classroom perception was evaluated using a structured questionnaire. Appropriate statistical tests were applied, with $p<0.05$ considered significant.
Results: A total of 60 students participated, with 30 students in each group. In Test 1, the mean score was higher in Group F after flipped classroom teaching than in Group E after traditional teaching. After crossover, the mean Test 2 score was higher in Group E following flipped classroom teaching than in Group F following traditional teaching (8.03±1.45 vs. 6.87±1.63). In Group E, the mean score increased significantly by 29.56% after exposure to the flipped classroom method ($p<0.001$), whereas the change in Group F was not statistically significant ($p=0.192$).
Conclusions: The flipped classroom method improved students' academic performance and short-term knowledge retention compared with traditional didactic teaching. Students also showed a favourable perception of this approach, supporting its use as a student-centred teaching strategy in physiology.

Keywords: Flipped classroom, Physiology education, Medical students, Academic performance, Knowledge retention, Medical education

INTRODUCTION

Physiology is a fundamental discipline in medical education because it explains the mechanisms that maintain normal functioning of the human body. It provides the scientific basis for understanding disease processes, clinical manifestations and the effects of therapeutic interventions. Noble described physiology as the "logic of life," reflecting its role as an interconnected system of principles rather than merely a collection of facts.[1] Therefore, effective teaching of physiology should not remain limited to the transmission of factual information. It should help students understand relationships between different physiological processes, apply basic concepts to clinical situations and develop reasoning skills required for medical practice.

Conventionally, physiology has been taught mainly through didactic lectures in which the teacher delivers information and students remain largely passive recipients. The concept of reversing this conventional sequence was introduced by Lage et al who described an inverted

classroom in which students initially study the learning material outside the classroom and use classroom time for discussion, application and problem-solving.[2] This approach was important because it shifted the focus from content delivery to active student participation. The need for such a change is also supported by the observation that students' attention during a continuous lecture may decline considerably with time.[3] Instead of completely abandoning lectures, Richardson suggested that lectures should be modified by making them focused, interactive and supported by active learning activities.[4] Such changes are particularly relevant in science education, where higher-order thinking develops when learners are encouraged to analyse information, reflect on their understanding and solve meaningful problems.[5]

The flipped classroom gradually emerged as a structured teaching-learning method based on these principles. In this model, students receive selected learning material, such as recorded lectures, reading resources or presentations, before the scheduled class. Classroom time is then utilised for clarification of difficult concepts, peer interaction, problem-solving and application-based exercises. Fulton highlighted that this arrangement can improve student preparedness and allow classroom sessions to be used more effectively for active learning.[6] The approach was subsequently applied in health professions education by McLaughlin et al who redesigned a course using the flipped classroom model and reported favourable changes in student engagement and learning experience.[7]

The possible application of flipped classrooms in Indian medical colleges has also been discussed because conventional teaching in many institutions is conducted in large groups with limited opportunity for individual participation. Rajaratnam and Dcruz emphasised the potential value of this method in Indian medical education while also drawing attention to the need for appropriate planning, faculty preparation and suitable learning resources.[8] The flipped model may therefore be useful in addressing some limitations of lecture-based teaching, particularly when students are expected to understand and apply complex physiological concepts within a limited teaching schedule.

Evidence regarding flipped classroom teaching in medical education has continued to increase. A systematic review by Chen et al evaluated its effectiveness across medical education settings and found that the method was generally associated with favourable learner responses and educational outcomes, although variations were present in study design and implementation.[9] Rui et al compared flipped teaching with conventional instruction for undergraduate electrocardiogram learning through a randomized controlled study, demonstrating its relevance for topics requiring interpretation and applied reasoning.[10] A subsequent meta-analysis by Hew and Lo reported that flipped classroom teaching improved learning outcomes in health professions education when compared with traditional approaches.[11] Singh et al further described the flipped classroom as a method for engaging medical students by shifting basic content acquisition outside the classroom and reserving face-to-face sessions for active learning.[12]

Physiology-specific studies have also supported the use of this teaching strategy. Dodiya et al compared flipped classroom teaching with traditional classroom teaching among undergraduate medical students in physiology and reported favourable findings with the flipped approach.[13] Similarly, Angadi et al assessed the effectiveness of the flipped classroom among undergraduate medical students through an interventional study and demonstrated that it could be incorporated as an active teaching-learning method.[14] These studies are relevant because physiology contains many concept-heavy topics where students may benefit from prior exposure to the basic content before participating in classroom discussion.

The flipped classroom has not remained limited to undergraduate medical teaching. Joseph et al reported improved performance and satisfaction among nursing students taught anatomy and physiology through a flipped classroom approach.[15] Nair and Yadav also described its use in postgraduate medical teaching, where learners could review foundational content independently and utilise classroom time for advanced discussion and clinical application.[16] These findings indicate that the model can be adapted according to the academic level of learners and the complexity of the subject matter.

More recent work has examined the usefulness of flipped teaching for specific areas of physiology and for retention of knowledge. Prabhu and Prabhu applied a flipped pedagogical approach while teaching skeletal muscle physiology to undergraduate medical students and reported favourable learning outcomes.[17] Ji et al assessed both short-term and long-term influences of the flipped classroom on physiology learning, making knowledge retention an important outcome for evaluating this method.[18] Bhavsar et al compared flipped classroom teaching with traditional didactic teaching in medical students and found the approach useful as an alternative strategy for improving the learning process.[19]

Current studies have further explored whether student-centred flipped teaching can improve conceptual understanding and higher-order learning. Lu et al examined the effects of a student-centred flipped classroom in physiology education and supported its role in promoting active participation and application-oriented learning.[20] Sourg et al reported improvement in the academic achievement of medical students after implementation of the flipped classroom model.[21] The method has also been extended to clinical preparation. Congdon et al used an upfront flipped-classroom curriculum to prepare medical students for a paediatric clerkship, demonstrating how pre-class learning and classroom application may assist students in linking theoretical knowledge with clinical responsibilities.[22]

Despite increasing evidence, the effectiveness of the flipped classroom may vary according to the subject, learning resources, student preparation, faculty involvement and manner of implementation. There is therefore a need to evaluate the method within individual medical institutions rather than assuming that findings from one setting will apply uniformly to another. In physiology, assessment should include not only immediate academic performance but also retention of knowledge and student's perception of the teaching method.

The present prospective study was therefore undertaken to Study Flipped Classroom paradigm in facilitating the learning of physiology in medical students. The primary objective was to compare medical student's performance and knowledge retention in flipped classroom with didactic classroom in Physiology. The secondary objective was to assess the perception of medical students regarding the flipped classroom teaching method. It was hypothesised that the Flipped Classroom paradigm improves the learning in medical students.

METHODS

Study design and setting

This prospective crossover study was conducted in the Department of Physiology, King George's Medical University, Lucknow, India, from August 2024 to July 2025.

Ethical considerations

The study was initiated after obtaining approval from the Institutional Ethics Committee, King George's Medical University, Lucknow, Uttar Pradesh, India (Approval No. 1987/Ethics/2024, dated 29 October 2024; Ref. code: XXV-PGTSC-IIA/P34). Written informed consent was obtained from all participants before enrolment, and all study procedures were conducted in accordance with the approved ethical protocol.

Study participants

First-year Bachelor of Medicine and Bachelor of Surgery students of King George's Medical University, Lucknow, were considered eligible for participation.

Inclusion criterion

First-year MBBS students of King George's Medical University, Lucknow, were included in the study.

Exclusion criteria

Students who did not attend the traditional didactic or flipped classroom sessions and who did not study the learning material provided before the flipped classroom session were excluded.

Sample size

The sample size was calculated on the basis of the variation in post-intervention scores obtained by students in the traditional and flipped classroom groups. The standard deviation of scores in the traditional teaching group was taken as 2.37, while the standard deviation in the flipped classroom group was taken as 2.60, as reported by Malhotra and Bhagat.[23]

The difference considered clinically significant was taken as the minimum of the two standard deviations. The design effect was taken as 1.0. A type I error of 5%, corresponding to a 95% confidence level, and a type II error of 10%, corresponding to 90% study power, were considered. Based on these parameters, the minimum required sample size was calculated as 30 students in each group.

Study procedure

First-year MBBS students fulfilling the eligibility criteria were identified and enrolled in the study. The enrolled students were randomly allocated into two groups, Group E and Group F, to minimise selection bias and obtain a comparable baseline distribution.

During the first phase of the study, Group E was taught through the traditional classroom teaching method, whereas Group F underwent the flipped classroom teaching method. For the flipped classroom session, learning material was provided before the class. Classroom time was subsequently used for interactive discussion and clarification of the concepts studied by the students.

Immediately after completion of the first teaching intervention, both groups appeared for Test 1. This test assessed immediate learning and academic performance following the respective teaching method. After an interval of two days, a retention test was conducted to assess short-term retention of knowledge.

A complete crossover was performed after 15 days. During the second phase, Group E was exposed to the flipped classroom teaching method, while Group F was taught through the traditional classroom teaching method.

Following completion of the second teaching intervention, both groups appeared for Test 2. This assessment allowed comparison of student performance following exposure to the two teaching methods. After a further interval of two days, a retention test was conducted to evaluate short-term knowledge retention.

After completion of all teaching sessions and assessments, student's perceptions regarding the flipped classroom teaching method were assessed using a structured feedback questionnaire administered to all participants. The study followed a crossover design (Figure 1).

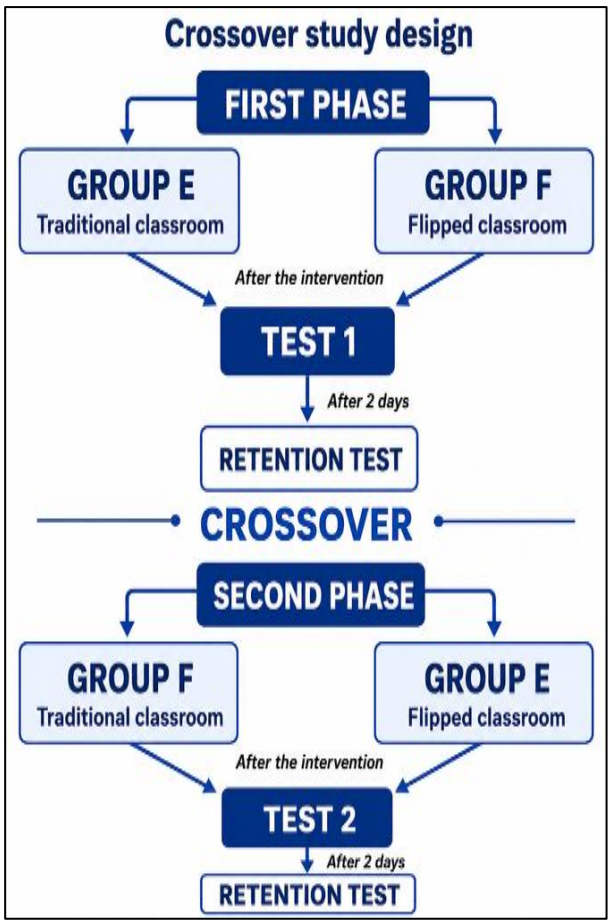


Figure 1: Crossover study design of traditional and flipped classroom teaching interventions.

Outcome parameters

The following parameters were assessed: student performance scores following the teaching interventions, short-term knowledge retention and students' perceptions of the flipped classroom teaching method.

Data collection

The collected data were compiled systematically and entered into a Microsoft Excel worksheet for statistical evaluation. The data were used to compare learning outcomes, knowledge retention and students' perceptions of the flipped classroom approach.

Statistical analysis

The scores obtained after traditional and flipped classroom teaching were compared within Group E and Group F according to the crossover design. Retention test scores obtained two days after each intervention were analysed to compare knowledge retention. Feedback responses were analysed to assess students' perception, acceptability and overall experience with the flipped classroom method. Continuous variables were expressed as mean±standard deviation, while categorical variables were presented as frequencies and percentages. Paired and unpaired t-tests, or their non-parametric equivalents, were applied as appropriate. The chi-square test was used for comparison of proportions. A $p<0.05$ was considered statistically significant.

RESULTS

A total of 60 first-year MBBS students participated in the study, with 30 students each in Group E and F. Group E included 18 (60.0%) male and 12 (40.0%) female students, while Group F included 19 (63.3%) male and 11 (36.7%) female students. Overall, 37 (61.7%) participants were male and 23 (38.3%) were female (Table 1).

During the first phase, Group E received traditional classroom teaching, whereas Group F received flipped classroom teaching. In Test 1, Grade A performance was observed in 5 (16.7%) students of Group E and 13 (43.3%) students of Group F. Grade B performance was noted in 17 (56.7%) students in each group. Eight (26.7%) students in Group E obtained Grade C, while no student in Group F was placed in this category. The mean Test 1 score was 6.20±1.30 in Group E and 7.30±0.99 in Group F. The median scores were 6 (range: 3-8) and 7 (range: 6-10), respectively (Table 2 and Figure 2).

Following crossover, Group E received flipped classroom teaching and Group F received traditional classroom teaching. In Test 2, 21 (70.0%) students in Group E and 12 (40.0%) students in Group F achieved Grade A. Grade B was obtained by 8 (26.7%) students in Group E and 12 (40.0%) students in Group F. Grade C performance was observed in 1 (3.3%) student in Group E and 6 (20.0%) students in Group F. The mean Test 2 score was 8.03±1.45 in Group E and 6.87±1.63 in Group F. The corresponding median scores were 8 (range: 5-10) and 7 (range: 3-9) (Table 3 and Figure 3).

Within Group E, the mean performance score increased from 6.20±1.30 in Test 1 after traditional teaching to 8.03±1.45 in Test 2 after flipped classroom teaching. The mean increase was 1.833±1.949, corresponding to a 29.56% improvement. This change was statistically significant (paired t-test, $t=-5.152$; $p<0.001$) (Table 4 and Figure 4).

Within Group F, the mean score decreased from 7.30±0.99 in Test 1 after flipped classroom teaching to 6.87±1.63 in Test 2 after traditional teaching. The mean change was -0.433±1.775, corresponding to a reduction of 5.94%. This difference was not statistically significant (paired t-test, $t=-1.337$; $p=0.192$) (Table 4 and Figure 5).

The findings showed that the group exposed to the flipped classroom method had higher mean performance scores and a greater proportion of students in Grade A during both phases of the crossover study.

Table 1: Intergroup comparison of gender distribution.

Gender	Group E, (n=30) (%)	Group F, (n=30) (%)	Total, (n=60) (%)
Male	18 (60.0)	19 (63.3)	37 (61.7)
Female	12 (40.0)	11 (36.7)	23 (38.3)

Table 2: Intergroup comparison of performance level and mean score in test 1.

Performance level	Group E, (n=30) (%)	Group F, (n=30) (%)	Total, (n=60) (%)
Grade A (score 8-10)	5 (16.7)	13 (43.3)	18 (30.0)
Grade B (score 6-7)	17 (56.7)	17 (56.7)	34 (56.7)
Grade C (score ≤5)	8 (26.7)	0 (0.0)	8 (13.3)
Mean score±SD	6.20±1.30	7.30±0.99	6.75±1.27
Median (range)	6 (3-8)	7 (6-10)	7 (3-10)

Table 3: Intergroup comparison of performance level and mean score in test 2 after crossover.

Performance level	Group E, (n=30) (%)	Group F, (n=30) (%)	Total, (n=60) (%)
Grade A (score 8-10)	21 (70.0)	12 (40.0)	33 (55.0)
Grade B (score 6-7)	8 (26.7)	12 (40.0)	20 (33.3)
Grade C (score ≤5)	1 (3.3)	6 (20.0)	7 (11.7)
Mean score±SD	8.03±1.45	6.87±1.63	7.45±1.64
Median (range)	8 (5-10)	7 (3-9)	8 (3-10)

Table 4: Intragroup change in performance scores from test 1 to 2.

Assessments	Group E, mean±SD	Group F, mean±SD
Test 1 score	6.20±1.30	7.30±0.99
Test 2 score	8.03±1.45	6.87±1.63
Mean change from test 1-2	1.833±1.949	-0.433±1.775
Percentage change	29.56%	-5.94%
Paired t test	T=-5.152; p<0.001	T=-1.337; p=0.192

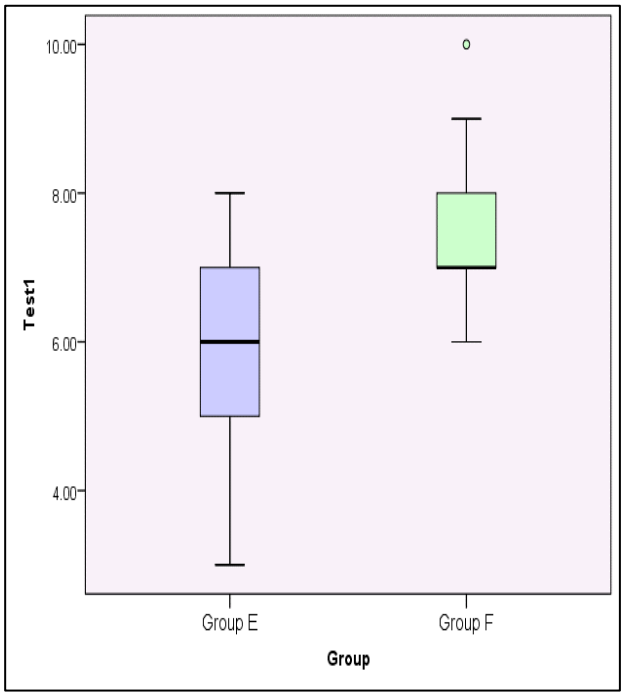


Figure 2: Box plot showing comparison of performance level of first test.

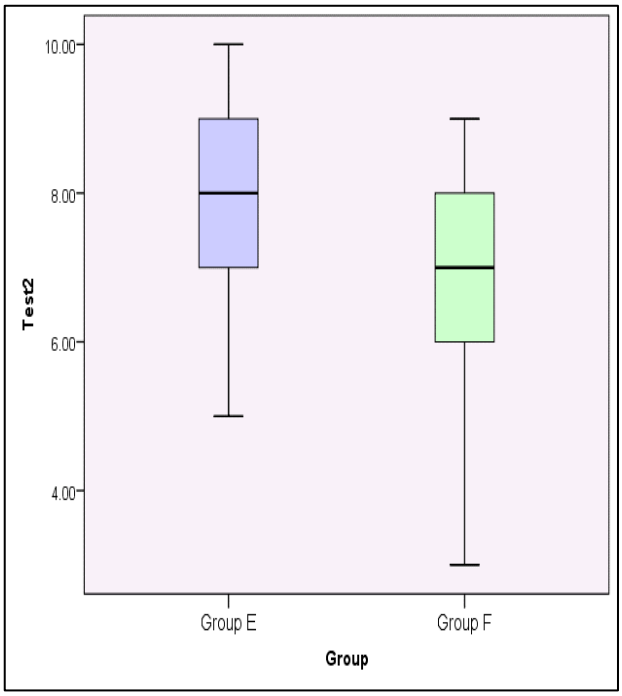


Figure 3: Comparison of performance level on second test.

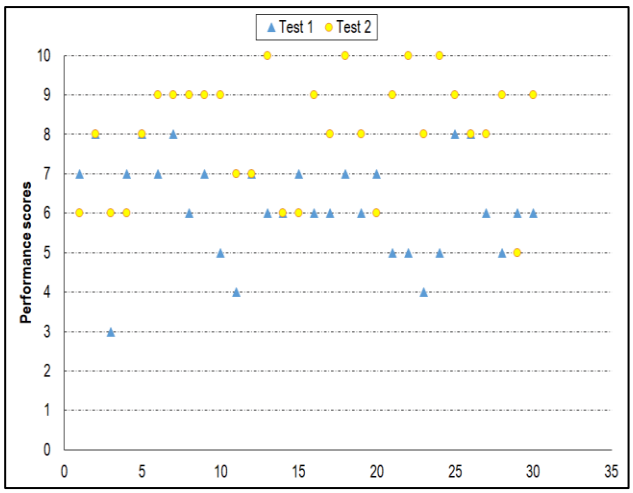


Figure 4: Test 1 and 2 performance scores of group E students.

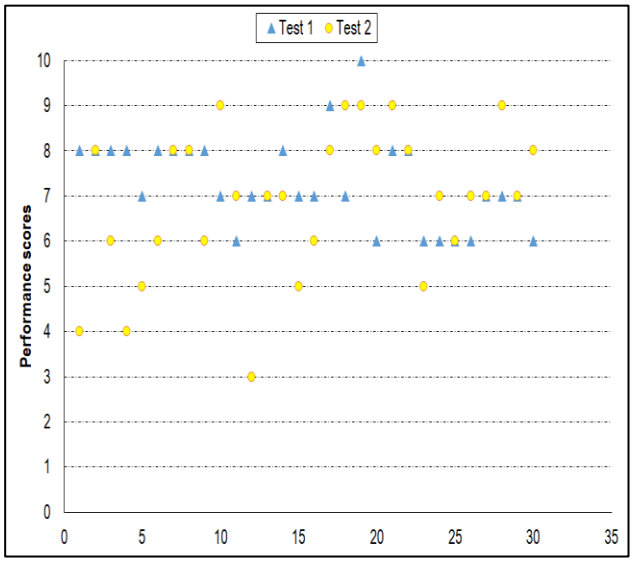


Figure 5: Test 1 and 2 performance scores of group F students.

DISCUSSION

The present prospective crossover study assessed the effect of flipped classroom teaching on the performance of first-year MBBS students in physiology. During the first phase, Group F, which received flipped classroom teaching, obtained a higher mean score than Group E, which received traditional teaching. After crossover, Group E achieved a higher mean score following flipped classroom teaching than Group F following traditional teaching. Within Group E, the mean score increased from 6.20±1.30 to 8.03±1.45, representing a 29.56% improvement, and this change was statistically significant. In Group F, the mean score decreased slightly after shifting from flipped to traditional teaching, but the change was not statistically significant. Thus, the findings mainly indicate better immediate academic performance during exposure to the flipped classroom method.

The flipped classroom differs from the conventional lecture because students study the basic content before attending the classroom session. The available class time can then be used for clarification, interaction and application of concepts. McLaughlin et al observed increased student learning, attendance and perceived value after redesigning a health-professions course through the flipped classroom approach.[7] The opportunity to review the learning material at an individual pace before class may help students enter the session with a basic understanding of the topic. This becomes useful in physiology, where learning often depends on linking several mechanisms rather than recalling isolated facts.

The present findings are comparable with those reported by Dodiya et al who compared flipped and traditional classroom teaching among undergraduate medical students in physiology. Their study found a statistically significant advantage with the flipped classroom method.[13] The crossover pattern observed in the present study also supports this trend. Group E improved after changing from traditional to flipped teaching, while Group F had a small reduction after changing from flipped to traditional teaching.

Angadi et al evaluated flipped classroom teaching among undergraduate medical students through an interventional crossover study. They reported that the flipped approach effectively engaged students in the learning process and improved their performance and perception of the learning experience.[14] Bhavsar et al also concluded that the flipped classroom was beneficial for medical students and enhanced their learning compared with traditional didactic teaching.[19] These observations are in agreement with the higher scores recorded during the flipped classroom phases of the present study.

The distribution of performance grades further supported the score-based findings. In Test 1, 43.3% of students in the flipped classroom group achieved Grade A compared with 16.7% in the traditional teaching group. No student exposed to the flipped classroom obtained Grade C, whereas 26.7% of students taught by the traditional method were placed in this category. After crossover, 70.0% of Group E students achieved Grade A following flipped teaching, compared with 40.0% of Group F students following traditional teaching. The reversal of the performance pattern after crossover suggests that the difference was related more closely to the teaching method than to a consistently better-performing group. However, as inferential p values for the intergroup comparisons were not available in the presented tables, these differences should be interpreted descriptively.

Similar findings have been reported in studies dealing specifically with physiology. Ji et al found that flipped classroom teaching significantly improved physiology learning outcomes compared with traditional lecture-based teaching.[18] Lu et al also observed improvement in physiology examination performance and usual academic

performance following a student-centred flipped classroom intervention.[20] Both studies support the present observation that physiology students may perform better when preliminary content learning is followed by active classroom engagement.

The usefulness of the flipped classroom has also been demonstrated for applied and interpretation-based topics. Rui et al in a randomized controlled study of undergraduate electrocardiogram learning, reported better learning outcomes with the flipped classroom approach than with traditional teaching.[10] This is relevant because electrocardiogram interpretation requires students to apply physiological concepts rather than depend only on factual recall. In the present study, improved scores during flipped teaching may similarly reflect better engagement with concept-based learning, although the specific cognitive level of the assessment questions was not separately analysed.

The findings are consistent with the systematic review by Chen et al and the meta-analysis by Hew and Lo, which reported favourable outcomes with flipped classroom teaching in medical and health-professions education.[9,11] In the present study, Group E showed a significant improvement after switching to flipped teaching ($p<0.001$), whereas the decrease in Group F after switching to traditional teaching was not statistically significant ($p=0.192$). However, period and carryover effects were not analysed separately, and the results should therefore be interpreted cautiously.

Joseph et al reported improved performance and satisfaction among nursing students who received flipped classroom teaching in anatomy and physiology.[15] Their findings suggest that the benefit of this approach is not restricted to one medical discipline or one category of health-professions learners. The common feature is the use of pre-class preparation followed by interactive classroom learning, which may permit more effective utilisation of contact time.

The differing changes between groups should not be interpreted as evidence that traditional teaching necessarily reduces performance. The results indicate an association between flipped classroom exposure and improved performance in Group E, although teaching sequence, topic characteristics and student preparation were not analysed separately.

The crossover design was a strength because both groups were exposed to the traditional and flipped classroom methods. This reduced the possibility that the findings were entirely due to fixed differences between Group E and Group F. Random allocation and equal group sizes also provided a balanced study structure. At the same time, the study had certain limitations. It was conducted at a single institution with 60 first-year MBBS students, which may limit generalisability. The presented analysis did not separately estimate period or carryover effects. Knowledge retention was assessed after two days, and therefore the findings cannot establish long-term retention. In addition, the currently presented tables do not provide inferential comparisons between the two groups for Test 1 and 2.

The present study demonstrates that flipped classroom teaching was associated with higher immediate performance scores in physiology. The significant improvement observed in Group E after crossover, along with the higher proportion of Grade A scores during both flipped classroom phases, supports its use as a student-centred teaching approach. It may be incorporated alongside conventional teaching to provide greater opportunity for preparation, interaction and application of physiological concepts. Larger multicentric studies with longer retention assessment and analysis of crossover effects would help establish the consistency and long-term educational value of this method.

Limitations

The present study had certain limitations. It was conducted at a single institution with a relatively small sample of 60 first-year MBBS students, which may limit the generalisability of the findings. Knowledge retention was assessed only after two days, so long-term retention could not be evaluated. Although a crossover design was used, possible period and carryover effects were not analysed separately. In addition, the study primarily assessed performance scores and student perception, while other factors such as individual learning style, prior academic ability, level of pre-class preparation and time spent on study material were not independently examined.

CONCLUSION

The flipped classroom method was associated with significantly better academic performance than traditional didactic teaching during both phases of the crossover study. Students exposed to the flipped approach achieved higher mean scores in Test 1 and after crossover in Test 2. Group E showed a significant 29.56% improvement after shifting from didactic to flipped teaching, whereas Group F showed a small non-significant decline after moving from flipped to traditional teaching. Although the first retention assessment showed no significant difference, Group E demonstrated better retention during the second assessment. Students also reported a favourable perception of the flipped classroom method. These findings supported the hypothesis that the flipped classroom facilitates learning and can be used as an effective student-centred teaching strategy alongside conventional physiology teaching.

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REFERENCES

1. Noble D. Commentary: Physiology is the logic of life. Jpn J Physiol. 2004;54(6):509-10.
2. Lage MJ, Platt GJ, Treglia M. Inverting the classroom: a gateway to creating an inclusive learning environment. J Econ Educ. 2000;31(1):30-43.
3. Wilson K, Korn JH. Attention during lectures: beyond ten minutes. Teach Psychol. 2007;34(2):85-9.
4. Richardson D. Don't dump the didactic lecture; fix it. Adv Physiol Educ. 2008;32(1):23-4.
5. Barak M, Shakhman L. Fostering higher-order thinking in science class: teachers' reflections. Teach Educ. 2008;14(3):191-208.
6. Fulton K. Upside down and inside out: flip your classroom to improve student learning. Learn Lead Technol. 2012;39(8):12-7.
7. McLaughlin JE, Roth MT, Glatt DM. The flipped classroom: a course redesign to foster learning and engagement in a health professions school. Acad Med. 2014;89(2):236-43.
8. Rajaratnam N, Dcruz S. Is the time right to start using flipped classrooms in Indian medical colleges? J Clin Diagn Res. 2015;9(9):JL01-2.
9. Chen F, Lui AM, Martinelli SM. A systematic review of the effectiveness of flipped classrooms in medical education. Med Educ. 2017;51(6):585-97.
10. Rui Z, Lian-Rui X, Rong-Zheng Y, Jing Z, Xue-Hong W, Chuan Z. Friend or foe? Flipped classroom for undergraduate electrocardiogram learning: a randomized controlled study. BMC Med Educ. 2017;17(1):53.
11. Hew KF, Lo CK. Flipped classroom improves student learning in health professions education: a meta-analysis. BMC Med Educ. 2018;18(1):38.
12. Singh K, Mahajan R, Gupta P, Singh T. Flipped classroom: a concept for engaging medical students in learning. Indian Pediatr. 2018;55(6):507-12.
13. Dodiya D, Vadasmiya DS, Diwan J. A comparative study of flip classroom teaching method versus traditional classroom teaching method in undergraduate medical students in physiology. Natl J Physiol Pharm Pharmacol. 2019;9:551-5.
14. Angadi NB, Kavi A, Hashilkar NK. Effectiveness of flipped classroom as a teaching-learning method among undergraduate medical students: an interventional study. J Educ Health Promot. 2019;8:211.
15. Joseph MA, Roach EJ, Natarajan J, Karkada S, Cayaban ARR. Flipped classroom improves Omani nursing students' performance and satisfaction in anatomy and physiology. BMC Nurs. 2021;20(1):1.
16. Nair A, Yadav AK. Use of flipped classroom for the teaching of postgraduate students: an experience. Med J Dr DY Patil Vidyapeeth. 2021;14(6):652-5.
17. Prabhu R, Prabhu G. Flipped pedagogical approach in teaching skeletal muscle physiology for undergraduate medical students. Indian J Physiol Pharmacol. 2022;66:211-7.
18. Ji M. Flipped classroom: short- and long-term influences on physiology learning effectiveness. Front Public Health. 2022;10:835810.
19. Bhavsar MH, Javia HN, Mehta SJ. Flipped classroom versus traditional didactic classroom in medical teaching: a comparative study. Cureus. 2022;14(3):e23657.
20. Lu C, Xu J, Cao Y, Zhang Y, Liu X, Wen H, et al. Examining the effects of student-centered flipped classroom in physiology education. BMC Med Educ. 2023;23(1):233.
21. Sourg HAA, Satti S, Ahmed N, Ahmed ABM, Ahmed AB. Impact of flipped classroom model in increasing the achievement for medical students. BMC Med Educ. 2023;23(1):287.
22. Congdon M, Goldstein L, Maletsky KD, Craven M, Rose S, Devon EP. Pediatric intersession: an upfront flipped-classroom curriculum to promote pediatric clerkship readiness. J Med Educ Curric Dev. 2024;11:23821205241229774.
23. Malhotra AS, Bhagat A. Flipped classroom for undergraduate medical students in India: are we ready for it? Adv Physiol Educ. 2023;47(4):694-8.

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