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The Effect of a Flipped Classroom Intervention on Student Engagement and Comprehension among Third-Year Medical Students

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Abstract

Cerebrovascular emergencies, such as stroke, require rapid recognition and sound clinical decision-making, making them among the most complex topics in the preclinical medical curriculum. This study aimed to examine the effect of a flipped classroom intervention on student engagement and comprehension among third-year medical students. A quasi-experimental study using a nonequivalent control group pretest–posttest design was conducted in April 2026 among 84 students at the Faculty of Medicine, Universitas Islam Malang. Participants were assigned to an intervention group (n = 42) and a control group (n = 42) during a lecture on cerebrovascular emergencies. Student engagement was assessed using a modified version of the National Survey of Student Engagement (NSSE), while comprehension was evaluated using a 50-item multiple-choice test. Data were analyzed using the Wilcoxon signed-rank test and the Mann–Whitney U test. Posttest results demonstrated significantly higher levels of student engagement and comprehension in the intervention group than in the control group. These findings suggest that the flipped classroom approach is a promising instructional strategy for enhancing student engagement and comprehension of complex topics in preclinical medical education.

INTRODUCTION

Medical education in Indonesia requires students to develop a thorough understanding of fundamental concepts and demonstrate critical thinking skills when solving clinical problems. Competency-based curricula therefore emphasize student-centered learning approaches (Yang, 2024). In practice, however, many medical schools continue to rely heavily on teacher-centered lectures, potentially limiting student engagement and active participation in the learning process (Altun, 2023). The flipped classroom is an instructional model that may help address this gap. In this model, students independently study core learning materials before class through presentation slides, assigned readings, or structured learning activities, while face-to-face sessions focus on discussions, problem-solving activities, and the application of theoretical concepts under the guidance of a facilitator (Chen, 2025; Shi, 2025; Yalew, 2025).

International studies have reported that the flipped classroom approach enhances behavioral, social, and cognitive engagement, as well as academic achievement, compared

with conventional instructional methods (Cagas, 2025; Faro, 2024). Studies conducted in Indonesia have similarly demonstrated favorable learning outcomes, particularly when addressing complex topics within medical curricula (Meliala, 2023; Mujiburrahman et al., 2025). At the Faculty of Medicine, Universitas Islam Malang (FK UNISMA), an online flipped learning approach implemented in the Hematology Physiology Block demonstrated positive effects on academic performance and student satisfaction (Mahmudah, 2022). Nevertheless, evidence regarding the effectiveness of face-to-face flipped classroom implementation across curricular blocks with different content characteristics remains limited.

The need for further evidence is reinforced by local academic performance data. During the 2025 academic year, 52 of 117 third-year medical students (44.4%) did not achieve the minimum passing grade in the Central and Peripheral Nervous System Pathology Block. Third-year medical students are in the preclinical phase of their education, during which foundational biomedical knowledge must be integrated with clinical reasoning and decision-making skills. Cerebrovascular emergencies represent a particularly challenging topic because they require a comprehensive understanding of underlying pathophysiological mechanisms, integration of multidisciplinary knowledge, and the application of theoretical concepts to clinical scenarios. To date, no study at FK UNISMA has directly compared student engagement and comprehension between flipped classroom and conventional instructional approaches in the context of cerebrovascular emergency education. Therefore, the novelty of the present study lies in implementing a face-to-face flipped classroom approach for teaching cerebrovascular emergencies and simultaneously evaluating two key learning outcomes: student engagement and comprehension.

This study aimed to examine the effect of a flipped classroom intervention on student engagement and comprehension and to compare its effectiveness with that of conventional instruction among third-year medical students at FK UNISMA. The anticipated benefits include providing an evidence-based rationale for integrating the flipped classroom approach into complex preclinical medical topics, offering practical guidance for lecturers in designing effective pre-class and in-class learning activities, and establishing a reference for institutional curriculum development. Furthermore, the findings may have implications for instructional practices in other curricular blocks with similar content characteristics and provide a foundation for future research investigating long-term knowledge retention, clinical reasoning development, and the transfer of learning to clinical practice.

METHOD

This quantitative study employed a quasi-experimental nonequivalent control group pretest–posttest design and was conducted in April 2026 at the Faculty of Medicine, Universitas Islam Malang (FK UNISMA). The study population consisted of third-year medical students from the 2023 cohort who attended the Central and Peripheral Nervous System Pathology Block during the 2025/2026 academic year. Students were included if they attended the cerebrovascular emergency lecture, agreed to participate, and completed all study procedures. Students repeating the course or failing to complete the study procedures were excluded. Total sampling resulted in 84 participants.

Participants were stratified by sex, age (⩽20 and >20 years), and grade point average (GPA; ⩽3.00 and >3.00), followed by proportional allocation into intervention and control groups at a 1:1 ratio, with 42 students in each group. Baseline characteristics were comparable between the groups in terms of sex (p = 0.321), age (p = 0.825), and GPA (p = 0.825).

The intervention group received lecture slides one day before the scheduled session as part of the pre-class preparation. During the face-to-face session, participants completed a pretest and engaged in small-group discussions of clinical cases involving cerebrovascular emergencies, facilitated by the lecturer. The control group received conventional lecture-based instruction. After data collection was completed, the control group was provided with the same learning materials to ensure equitable access to educational resources.

Student engagement was assessed using a modified version of the National Survey of Student Engagement (NSSE), comprising 50 items measuring behavioral, emotional, and cognitive engagement on a five-point Likert scale. Item scores were aggregated into a total engagement score, with higher scores indicating greater engagement. Student comprehension was assessed using 20 single-best-answer multiple-choice questions (MCQs) developed from a lecturer-approved assessment blueprint covering conceptual understanding, theoretical application, and basic clinical case analysis. Comprehension scores were converted to a 0–100 scale and categorized as high (>65%), moderate (50–65%), or low (0.05.

RESULTS AND DISCUSSION

Respondent Characteristics

A total of 84 students participated, with 42 students in each group. As shown in Table 1, age, gender, and GPA showed no significant relationship with either student engagement or student understanding on the post-test (all p > 0.05).

Table 1. The Relationship between Respondent Characteristics and Categories of Student Engagement and Student Understanding

Characteristic	Student Understanding		Student Engagement		
	Post: High	*p*	Post: Medium	Post: High	*p*
Age ≤20 years	32 (43,2%)	0,425	3 (30.0%)	32 (43.2%)	0.425
Age >20 years	42 (56,8%)		7 (70.0%)	42 (56.8%)	
Male	20 (27,0%)	0,635	2 (20.0%)	20 (27.0%)	0.635
Female	54 (73,0%)		8 (80.0%)	54 (73.0%)	
GPA <3.00	29 (39,2%)	0,210	6 (60.0%)	29 (39.2%)	0.210
GPA ≥3.00	45 (60,8%)		4 (40.0%)	45 (60.8%)	

Note: Chi-square test; GPA = grade point average.

Table 2 shows that age, gender, and GPA were also not significantly associated with student engagement categories and post-learning understanding (all p > 0.05).

Student Engagement and Comprehension within Groups

In the control group, mean engagement rose from 36.0 to 39.6, a statistically significant change ($Z = -2.686$; $p = 0.007$). In the intervention group, mean engagement rose from 70.3 to 71.1, but the change was not significant ($Z = -0.691$; $p = 0.489$). For comprehension, the mean score of the control group increased from 54.0 to 85.5 without statistical significance ($Z = -0.691$; $p = 0.489$), whereas the intervention group improved significantly from 51.5 to 98.4 ($Z = -8.200$; $p < 0.001$), as presented in Table 2.

Table 2. Pretest and Posttest Comparison within Groups (Wilcoxon Signed-Rank Test)

Variable	Group	Pretest mean	Posttest mean	*Z*	*p*
Student engagement	Control	36.0	39.6	−2.686	0.007
	Intervention	70.3	71.1	−0.691	0.489
Comprehension	Control	54.0	85.5	−0.691	0.489
	Intervention	51.5	98.4	−8.200	<0.001

Note: n = 42 in each group.

Comparison between Groups

Pretest-Posttest Scores Between Groups and Differences in Understanding Between Intervention and Control Groups

There was an increase in understanding scores from the pretest to the posttest in both the control and intervention groups. In the control group, the increase in understanding scores was not significant (p=0.489), whereas in the intervention group, the increase was significant (p<0.001). Furthermore, there was a significant difference in posttest scores between the control and intervention groups (p=0.003), with the intervention group having a higher mean posttest score than the control group.

Table 3. Comparison of Understanding Between the Intervention Group and the Control Group**)**

Variabel	Group/Time	N	Rata-rata	Z	*p*-value
pretest–posttest of control group understanding	Pretest	42	54	−0,691	0,489
	Posttest	42	85,5		
pretest–posttest of the intervention group's understanding	Pretest	42	51,5	−8,200	<0,001
	Posttest	42	98,4		
Difference in post-test scores between groups	control	42	85,5	−2,967	0,003
	Intervensi	42	98,4		

Note: The Wilcoxon test showed a non-significant increase in understanding in the control group (p=0.489) and a significant increase in the intervention

group (p<0.001). The Mann–Whitney test showed a significant difference in post-test scores between the two groups (p=0.003).

Table 4 shows that the posttest engagement of the intervention group had a higher mean rank (62.14) than that of the control group (22.86), with $Z = -7.382$ and $p < 0.001$. The posttest comprehension of the intervention group also had a higher mean rank (49.19) than that of the control group (35.81), with $Z = -2.967$ and $p = 0.003$. Therefore, H3 was accepted.

Table 4. Posttest Comparison between Groups (Mann–Whitney U Test)

Variable	Group	n	Mean rank	*Z*	*p*
Student engagement	Control	42	22.86	−7.382	<0.001
	Intervention	42	62.14		
Comprehension	Control	42	35.81	−2.967	0.003
	Intervention	42	49.19		

Note: A higher mean rank indicates a higher score.

Respondent Characteristics, Engagement, and Comprehension

Age, sex, and GPA showed no consistent association with engagement or comprehension. Older students and those with a higher GPA tended to fall into the high categories, possibly because of longer academic experience and more established learning habits. However, the respondents came from the same cohort and stage of education, so their experience was relatively homogeneous. A large multicentre study likewise showed that individual characteristics should be interpreted together with the learning environment, because engagement is not shaped by personal attributes alone (Huang, 2024). The educational environment is also related to the behavioural, cognitive, and emotional engagement of health professions students (Kassab, 2024). Similarly, performance differences are more closely linked to learning strategies than to sex or age (Saxena, 2024), and GPA reflects cumulative achievement across many courses rather than comprehension of a single topic (Liu, 2022).

Student Engagement

Within the intervention group, engagement did not change significantly. Several factors may explain this result. The success of the pre-class phase depends on student readiness, motivation, and self-regulation, and providing material before class does not guarantee that every student studies it. The intervention was delivered in a single session, which may be too short to change a multidimensional construct such as engagement. In addition, the intervention group already showed high engagement at baseline, which left limited room for improvement. Mere attendance in learning activities does not necessarily reflect active involvement (Mishall, 2025), and flipped instruction needs activity designs that consistently stimulate behavioural, emotional, and cognitive engagement (Sourg, 2023).

Nevertheless, posttest engagement was significantly higher in the intervention group than in the control group. This finding is consistent with the constructivist basis of the model, in which the lecturer acts as a facilitator and students construct knowledge through interaction with peers (Mishall, 2025). Pre-class study allows students to prepare independently, so that class time can focus on case discussion and problem solving, which stimulates higher-order thinking (Paralikar, 2022). Previous studies have reported that flipped instruction increases motivation, peer learning, and engagement among medical

students (Ahamed, 2025) and improves engagement in higher education (Faro, 2024). Differences in instruments should be noted, because many earlier studies used satisfaction or perception surveys, whereas this study used a multidimensional engagement questionnaire; collaborative engagement measures capture different aspects of the construct (Xu, 2024). Even so, a quasi-experimental study of 100 medical students also found that the flipped classroom group outperformed the lecture-based group (Mengesha, 2024).

Student Comprehension

Comprehension improved significantly in the intervention group but not in the control group, and the posttest scores differed significantly between the groups. Flipped instruction gives students repeated exposure to the material, first through independent study and then through discussion, case solving, and immediate feedback from the facilitator. This process helps students to connect prior knowledge with clinical problems in cerebrovascular emergency. The result agrees with a meta-analysis of 127 studies involving 21,171 participants, which found higher knowledge scores with flipped instruction than with conventional methods (Chen, 2025), and with a meta-analysis in clinical medical education that reported higher theory, composite, and skill scores (Shi, 2025).

A quasi-experimental study in undergraduate medical education also showed similar baseline scores in both groups but a larger knowledge gain in the flipped classroom group (Patnaik, 2025), a pattern consistent with the present findings. In contrast, other studies reported that the control group still improved, although to a lesser extent than the flipped group (Mengesha, 2024). The complexity of the neurological content and the limited opportunity for active collaboration in conventional lectures may explain the smaller improvement in the control group of this study.

Effectiveness of the Flipped Classroom

Taken together, the between-group comparison provides the clearest evidence of effectiveness. Although the within-group change in engagement was not significant, both posttest engagement and posttest comprehension were significantly higher in the intervention group. The combination of independent pre-class study and active in-class learning allows students to prepare, apply, and clarify knowledge, and engagement and achievement can therefore improve together (Patnaik, 2025). Systematic evidence in health professions education further confirms that flipped classrooms generally improve academic performance compared with conventional teaching (Naing, 2023).

CONCLUSION

The flipped classroom intervention resulted in significantly higher posttest levels of student engagement and comprehension than conventional instruction among third-year medical students. Comprehension improved significantly within the intervention group, whereas the within-group change in student engagement was not statistically significant. These findings suggest that the flipped classroom approach is a promising instructional strategy for teaching complex preclinical topics, such as cerebrovascular emergencies. Lecturers are encouraged to incorporate this approach into instructional activities requiring conceptual understanding, critical thinking, and active discussion. Furthermore, medical education institutions may consider integrating the flipped classroom approach into

curriculum development to enhance student engagement and comprehension in preclinical medical education.

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CONFLICT OF INTEREST

The authors declare that this research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

AUTHOR CONTRIBUTION

All authors contributed to the preparation and writing of this article.

GENERATIVE ARTIFICIAL INTELLIGENCE USAGE STATEMENT

In the preparation of this manuscript, the authors utilized Artificial Intelligence (AI) solely for the purposes of improving grammar and checking language usage.

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