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Flipped Classroom Model Versus Conventional Teaching in Neurology Clerkship: A Comparative Randomized Study

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Abstract

A randomized prospective study evaluated the educational impact of a flipped-classroom (FC) model versus conventional didactic teaching in a 4-week neurology clerkship among 104 medical students. Participants were randomized to FC (n = 49)—comprising pre-class videos, readings, and interactive in-class clinical reasoning sessions—or traditional lecture-based instruction (n = 55). Primary outcomes included NBME shelf exam scores, faculty-rated clinical proficiency, self-directed learning (SDL) behaviors, and student satisfaction. Baseline characteristics were comparable. End-of-clerkship NBME scores showed no significant difference after adjustment (adjusted mean difference 2.3 points; 95% CI –0.4 to 4.8; p = 0.07). The FC group demonstrated significantly better clinical skill ratings (4.2 ± 0.5 vs. 3.9 ± 0.7; p = 0.03) and future housestaff potential (4.8 ± 0.3 vs. 4.5 ± 0.6; p = 0.03). The traditional group displayed more SDL behaviors (42% vs. 12%; p = 0.001) and greater study hours (6.1 vs. 3.8 hrs; p = 0.03). Satisfaction and OSCE performance were equivalent (p > 0.20). Results show that while cognitive outcomes were similar, FC enhanced clinical skills whereas conventional instruction fostered SDL. Blended models are

recommended to harness both strengths.

Keywords: flipped classroom; neurology education; clinical skills; self-directed learning.

Introduction

Medical clerkships aim to integrate theoretical knowledge with clinical competency. In neurology, effective teaching is pivotal for mastery of intricate neurological evaluation and diagnostic reasoning. Traditional lecture-based formats—though informative—may hinder active application and hands-on skill development[1].

A progressive teaching strategy is the flipped-classroom (FC) model, which frontloads knowledge acquisition via asynchronous multimedia content, reserving in-class time for active learning, case discussions, and problem-solving[2]. This learner-centered modality can improve engagement and enhance clinical reasoning[3].

Within neurology education, evidence suggests FC formats promote faster theoretical coverage and higher clinician-assessed performance. A prospective controlled trial showed FC neurology bedside teaching did not enhance self-rated skills significantly but did reduce in-class theory recap time and improved faculty perception of student readiness[4].

Comparative studies of FC versus online-only instruction reveal FC students outperform in observed clinical skills, though online cohorts may engage more in SDL[5]. Furthermore, a 4-week virtual FC curriculum achieved non-inferior NBME shelf exam scores compared with a standard 4-week rotation[6].

Nevertheless, RCTs in required neurology clerkships comparing FC to conventional teaching with controlled randomization and a blend of objective and subjective outcomes remain insufficient. Clarifying these instructional advantages is critical for optimizing medical education frameworks and balancing clinical competence with independent learning strategies.

The current study examines whether FC improves clinical competence, knowledge acquisition, SDL, and satisfaction compared to conventional teaching in neurology clerkships, hypothesizing enhanced clinical and self-directed outcomes with FC alongside equivalent exam performance.

Methodology

This block-randomized controlled study was conducted from January to June 2024 at KMDC and Imran Idrees Hospital. A total of 104 third- and fourth-year medical students rotating through the required neurology clerkship were randomized into either the FC group (n = 49) or the

conventional teaching group (n = 55). Randomization occurred via sealed envelopes following ethical IRB approval and informed consent. Both groups received standard bedside clinical instruction; FC students additionally reviewed pre-class online modules (videos, reading materials) and participated in guided in-class clinical reasoning sessions. The conventional group attended traditional faculty-led didactic lectures. Baseline assessments included demographics and pre-clerkship knowledge tests. Outcomes assessed at week 4 included NBME shelf exam scores, faculty/resident clinical performance evaluations (rated 1–5 scale), SDL engagement (frequency of non-required assignments), study hours logged per week, end-of-clerkship satisfaction survey, and OSCE performance. Data were analyzed using t-tests, chi-square tests, and ANCOVA accounting for baseline knowledge differences. Significance was set at $p < 0.05$, and SPSS® v26 was used for all analyses.

Results

Table 1. Baseline Characteristics of Participants

Variable	FC (n=49)	Conventional (n=55)	p-value
Age (years)	25.3 ± 2.1	25.6 ± 2.2	0.52
Female, n (%)	27 (55%)	30 (55%)	0.99
Pre-clerkship knowledge*	27.6 ± 11	21.5 ± 10	0.003

*Knowledge assessment was based on a peer-reviewed content exam.

FC students exhibited significantly higher baseline knowledge, warranting adjustment in subsequent analyses.

Table 2. Primary and Secondary Outcomes

Outcome	FC	Conventional	p-value
NBME shelf exam score (post-ANCOVA)	Adjusted +2.3 pts (CI −0.4–4.8)	–	0.07
Faculty-rated clinical skills (1-5)	4.2 ± 0.5	3.9 ± 0.7	0.03
Future housestaff potential (1-5)	4.8 ± 0.3	4.5 ± 0.6	0.03
SDL engagement, n (%)	6 (12%)	23 (42%)	0.001

Outcome	FC	Conventional	p-value
Weekly study hours	3.8 ± 1.2	6.1 ± 1.5	0.03
End-of-clerkship satisfaction	Equivalent	Equivalent	> 0.20
OSCE score (1-5 overall)	Equivalent	Equivalent	> 0.20

FC improved clinical performance, while conventional favored SDL and study time.

Table 3. Satisfaction and OSCE Results

Measure	FC (%)	Conventional (%)	p-value
High satisfaction score	90%	88%	0.76
OSCE score ≥4	78%	74%	0.58

Both groups reported high satisfaction and comparable OSCE competency.

Discussion

This randomized study confirms that FC and conventional pedagogy produce equivalent knowledge acquisition as indicated by NBME scores, corroborating recent findings in virtual neurology curricula[7]. Adjusted outcomes showed no statistically meaningful difference, suggesting cognitive[8] objectives can be achieved via both modalities. Importantly, FC significantly enhanced clinically observable skills and future housestaff potential, echoing controlled prospective evidence that FC approaches bolster practical readiness[45]. Such improvements may stem from active engagement in reasoning tasks during in-class time. Conversely, conventional teaching fostered greater SDL behavior and study time—aligning with previous comparisons where traditional methods stimulated autonomy[9-12]. These effects highlight the trade-off between structured teaching and self-directed learning.

Both pedagogies yielded high satisfaction and successful OSCE outcomes, indicating student receptivity and competence unaffected by instructional format. These results align with meta-analyses that find no detriment in learning outcomes with FC when designed effectively[13-14]. Strengths include randomized design, multifaceted outcome assessments, and adjustment for baseline knowledge differences [15]. Limitations encompass single-center scope, moderate sample size, and inability to blind participants. Further studies should analyze long-term retention, cost-

effectiveness, and impact on other clinical rotations. These findings support integrating hybrid models combining FC for skill development with conventional methods to facilitate SDL, thereby tailoring neurology education to diverse learning goals.

Conclusion

The flipped-classroom model significantly enhances clinical competence in neurology clerkships while maintaining knowledge acquisition. Traditional instruction promotes greater self-directed learning. A blended approach may optimize both domains and improve overall educational outcomes.

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