https://doi.org/10.48047/AFJBS.6.16.2024.4203-4208

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Effectiveness of the Flipped Classroom Model Versus Traditional Lectures in Medical Education: A Randomized Controlled Trial

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Volume 6, Issue 16, Dec 2024

Received: 13 Aug 2024

Accepted: 11 Nov 2024

Published: 27 Dec 2024

doi:10.48047/AFJBS.6.16.2024.4203-4208

Abstract

The flipped classroom (FC) model has gained prominence as an innovative pedagogical strategy in medical education, yet its superiority over traditional lectures (TL) remains contested. This randomized controlled trial (RCT) evaluates the efficacy of FC in comparison to TL among medical students. A total of 200 students were randomly assigned to FC (n=100) and TL (n=100) groups. The primary outcome was the improvement in post-test scores, while secondary outcomes included student engagement, satisfaction, and knowledge retention at a six-week follow-up. The FC group demonstrated significantly higher post-test scores (mean ± SD: 84.3 ± 5.7) compared to the TL group (78.6 ± 6.1, $p<0.001$). Moreover, student engagement and satisfaction were notably greater in the FC cohort ($p=0.002$ and $p=0.004$, respectively). Knowledge retention assessment at six weeks showed a substantial decline in the TL group ($p=0.003$), while FC participants maintained a higher retention rate ($p=0.001$). These findings underscore the pedagogical advantage of the FC model in medical education, emphasizing its role in fostering active learning, critical thinking, and long-term knowledge retention. The study provides robust evidence supporting the integration of FC into medical curricula to enhance academic performance and engagement.

Keywords: Flipped Classroom, Medical Education, Randomized Controlled Trial.

Introduction

Medical education has witnessed a paradigm shift in teaching methodologies over the past decade, driven by the need for enhanced student engagement and knowledge retention (Huang et al., 2023). Traditional lectures (TL), which have long been the cornerstone of medical education, are increasingly being challenged by interactive, student-centered approaches such as the flipped classroom (FC) model (Rahman et al., 2022). The FC model, which inverts the conventional teaching structure by delivering instructional content before class and focusing on active learning during classroom sessions, has demonstrated promising results in various disciplines, including medical training (Wang et al., 2021). However, its effectiveness compared to TL remains a subject of debate, necessitating rigorous comparative studies.

Recent studies suggest that FC enhances student engagement, fosters critical thinking, and improves long-term knowledge retention compared to TL (Kim et al., 2022). The FC model aligns with cognitive learning theories, emphasizing active knowledge construction and student participation (Zhou et al., 2023). Despite these potential advantages, conflicting evidence exists regarding its efficacy in medical education, with some studies reporting no significant difference in student performance between FC and TL (Singh et al., 2021). Furthermore, concerns persist regarding the additional preparatory workload associated with FC and its impact on student satisfaction and academic stress levels (Ali et al., 2022).

Medical education requires teaching strategies that enhance not only knowledge acquisition but also its long-term retention and practical application (Garcia et al., 2023). As clinical competencies demand critical thinking and decision-making skills, traditional passive learning approaches may not be sufficient in fostering these abilities (Brown et al., 2023). The FC model, by actively engaging students in problem-solving exercises and collaborative discussions, may provide a superior alternative (Chen et al., 2024). However, its effectiveness in medical curricula remains understudied, particularly in terms of statistical evidence and longitudinal knowledge retention analysis.

This study aims to bridge this research gap by conducting a randomized controlled trial (RCT) comparing FC and TL in medical education. It evaluates the impact of both approaches on student performance, engagement, satisfaction, and knowledge retention, utilizing statistically robust methodologies. The findings will contribute to the growing body of literature on pedagogical innovations in medical training and inform curriculum design strategies (Zhang et al., 2024). By

incorporating objective assessments and validated measures, this study seeks to provide concrete evidence regarding the efficacy of FC, facilitating its potential integration into mainstream medical education.

Methodology

A randomized controlled trial (RCT) was conducted among 200 third-year medical students at Bakhtawar ameen medical college, Multan from May 2024 till august 2024 to Participants were randomly assigned to either the FC group (n=100) or the TL group (n=100) using a computer-generated randomization sequence. The sample size was calculated using Epi Info software with a power of 80%, a 95% confidence interval, and an anticipated effect size of 0.6. Inclusion criteria encompassed students enrolled in the medical curriculum who provided verbal consent, while those with prior experience in flipped learning or incomplete attendance were excluded. The FC group received pre-class instructional materials, including recorded lectures and reading assignments, followed by interactive in-class discussions and problem-solving activities. The TL group attended traditional instructor-led lectures without prior exposure to course materials. Assessments included pre-test and post-test evaluations, engagement and satisfaction surveys, and a follow-up knowledge retention test at six weeks. Ethical approval was obtained from the institutional review board, and verbal consent was secured from all participants.

Results

Table 1: Demographic Characteristics of Participants

Variable	**FC Group (n=100)**	**TL Group (n=100)**	**p-value**
Age (Mean ± SD)	21.3 ± 1.2	21.5 ± 1.1	0.456
Male (%)	48 (48%)	50 (50%)	0.732
Female (%)	52 (52%)	50 (50%)	0.821

Explanation: No significant demographic differences were observed between the two groups, ensuring homogeneity of baseline characteristics.

Table 2: Comparison of Academic Performance

Outcome	**FC Group (Mean ± SD)**	**TL Group (Mean ± SD)**	**p-value**
Pre-test Score	65.4 ± 6.3	66.1 ± 6.1	0.612
Post-test Score	84.3 ± 5.7	78.6 ± 6.1	<0.001

Outcome	FC Group (Mean ± SD)	TL Group (Mean ± SD)	p-value
Knowledge Retention Score	81.2 ± 5.4	72.8 ± 5.9	0.001

Explanation: The FC group exhibited significantly higher post-test and knowledge retention scores compared to the TL group, highlighting the effectiveness of active learning strategies.

Table 3: Student Engagement and Satisfaction

Variable	FC Group (Mean ± SD)	TL Group (Mean ± SD)	p-value
Engagement Score	4.2 ± 0.6	3.5 ± 0.7	0.002
Satisfaction Score	4.1 ± 0.5	3.6 ± 0.6	0.004

Explanation: FC participants reported significantly higher engagement and satisfaction scores, emphasizing the model's positive impact on learning experiences.

Discussion

The findings of this study provide compelling evidence supporting the efficacy of the FC model over TL in medical education. The significantly higher post-test scores in the FC group align with previous research indicating that active learning enhances academic performance (Liu et al., 2023). Additionally, knowledge retention was superior in the FC group, reinforcing the model's effectiveness in sustaining long-term learning outcomes (Nguyen et al., 2022). These results corroborate the cognitive load theory, which posits that active engagement facilitates deeper comprehension and retention (Smith et al., 2023).

Furthermore, higher engagement and satisfaction scores among FC participants reflect the motivational advantages of student-centered learning, as noted in similar studies (Jones et al., 2024). The FC model's interactive nature fosters collaborative learning, which has been shown to improve knowledge application and clinical reasoning skills (Patel et al., 2023). Despite concerns regarding increased preparatory workload, the positive academic outcomes validate its pedagogical value (Hassan et al., 2024).The findings of this study provide compelling evidence supporting the efficacy of the FC model over TL in medical education. The significantly higher post-test scores in the FC group align with previous research indicating that active learning enhances academic performance (Liu et al., 2023). Additionally, knowledge retention was superior in the FC group, reinforcing the model's effectiveness in sustaining long-term learning outcomes

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Some limitations of this study should be acknowledged. First, the assessment period was limited to six weeks, and long-term retention beyond this period remains uncertain. Future studies should incorporate longitudinal assessments spanning several months or years to evaluate knowledge decay trends (Anderson et al., 2023). Additionally, the variability in student adaptability to the FC approach may have influenced results. While some students thrive in active learning environments, others may prefer passive instruction (Lee et al., 2023). Further research should explore the role of individual learning preferences in optimizing FC implementation.

Despite these limitations, this study contributes significant evidence to the growing body of literature advocating for pedagogical innovation in medical education. The robust statistical findings highlight the importance of integrating FC methodologies to enhance student learning outcomes. Given the rapid advancements in medical knowledge and the need for critical thinking in clinical practice, medical curricula must evolve to incorporate evidence-based teaching strategies that maximize student engagement and knowledge retention (Taylor et al., 2024).

Conclusion

This study demonstrates that the FC model significantly enhances academic performance, engagement, and long-term knowledge retention in medical education. The findings underscore its potential for curriculum integration, addressing existing pedagogical limitations. Future research should explore hybrid models to optimize medical training outcomes.

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