



## Systematic Review



# The Effectiveness of Flipped Classroom Models in Undergraduate Medical Education: A Systematic Review

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## ABSTRACT

The flipped classroom has emerged as a progressive pedagogical model in undergraduate medical education, aiming to improve learning outcomes by combining self-directed pre-class learning with interactive in-class activities. Unlike traditional lectures, this method fosters active engagement, critical thinking, and practical skill development. **Objectives:** To evaluate the effectiveness of flipped classroom models in improving academic outcomes, student satisfaction, and skill acquisition among undergraduate medical students. **Methods:** A comprehensive literature search was conducted across PubMed, Springer Link, Science Direct, BMC, Wiley Online Library, and Taylor & Francis for studies published between January 2019 and August 2024. Eligible studies included undergraduate medical or allied health students exposed to flipped classroom models, with outcomes compared against traditional teaching methods. Data extraction and quality appraisal were performed using standardized tools, and results were synthesized narratively due to heterogeneity. **Results:** Most included studies reported improvements in academic performance, student satisfaction, and engagement. The flipped classroom was particularly effective in enhancing clinical reasoning and knowledge retention. However, some studies demonstrated variable outcomes depending on the quality of implementation and learner readiness. **Conclusions:** The flipped classroom approach shows considerable potential to strengthen undergraduate medical education. Its effectiveness is maximized when supported by structured implementation, faculty training, and strategies that foster self-regulated learning among students.

## INTRODUCTION

Over the past decade, medical education has undergone a substantial transformation in teaching methodologies, moving away from passive, lecture-based instruction to more interactive, student-centered models [1]. One such innovation is the flipped classroom, a blended learning approach that delivers theoretical content outside the classroom and utilizes in-class time for discussion,

application, and problem-solving [2]. Internationally, the flipped classroom has gained recognition for its effectiveness in improving both theoretical understanding and practical skills [3]. For instance, studies from Taiwan [4], the United States [5], and South Korea [6] have consistently reported enhanced knowledge retention, improved performance on assessments, and increased



learner satisfaction. A meta-analysis by Shi *et al.* further confirmed the flipped model's positive impact on medical education outcomes, particularly in anatomy, physiology, and clinical reasoning [7]. In the Pakistani context, the flipped classroom is gaining traction but remains underexplored. A notable study by Sultan *et al.* implemented an online flipped classroom during the COVID-19 pandemic at Aga Khan University, reporting significant improvements in both knowledge acquisition and student satisfaction [8]. Similarly, Shaikh *et al.* highlighted that the flipped approach improved students' engagement and critical thinking in a pharmacology course [9]. However, implementation across medical colleges in Pakistan remains inconsistent due to infrastructural limitations, lack of faculty training, and resistance to shifting from conventional pedagogies. Despite these promising findings, a number of concerns persist. The success of flipped classrooms depends heavily on students' motivation and their ability to engage with pre-class materials, as well as on faculty preparedness and curriculum alignment. Furthermore, there is a lack of standardized guidelines for implementation, and limited comparative evidence exists in low- and middle-income countries, including Pakistan. While international studies provide robust evidence supporting flipped classrooms in medical education, there is a clear gap in synthesized evidence evaluating their effectiveness specifically in undergraduate medical programs. Moreover, the inconsistent adoption and lack of localized research in Pakistan highlight the need for a comprehensive review. Although flipped classroom models are increasingly adopted in undergraduate medical education, existing evidence remains fragmented across disciplines, regions, and study designs. Many individual studies report positive outcomes, yet variations in implementation strategies, outcome measures, and learner contexts limit clear conclusions regarding overall effectiveness. Furthermore, there is limited synthesized evidence focusing specifically on undergraduate medical programs in low- and middle-income countries, including Pakistan. This highlights the need for a systematic evaluation of recent literature to provide consolidated evidence on academic performance, satisfaction, and skill development outcomes. This study aimed to assess the effectiveness of flipped classroom models in undergraduate medical education, focusing on student learning outcomes, satisfaction, and engagement.

## METHODS

This systematic review was conducted according to the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The objective was to evaluate the effectiveness of flipped classroom models in undergraduate medical education. A comprehensive

search was carried out across six electronic databases: PubMed, SpringerLink, ScienceDirect, BMC, Wiley Online Library, and Taylor and Francis. The search covered studies published between January 2019 and August 2024. Keywords were developed using a combination of Medical Subject Headings (MeSH) and free-text terms, including "flipped classroom," "medical education," "undergraduate," "active learning," "medical students," and "educational outcomes." Boolean operators (AND, OR) were applied to refine the results. Only studies published in English were included due to resource and feasibility constraints. The inclusion criteria for this systematic review were defined using the PICOS framework. Eligible studies were those involving undergraduate medical, nursing, or allied health students as participants. The intervention of interest was the flipped classroom approach, which included strategies such as pre-class preparation, video-based or online modules, and in-class active learning activities. The comparator was conventional lecture-based teaching or other traditional instructional methods. Eligible studies were required to report at least one relevant outcome, including academic performance, knowledge retention, student engagement or motivation, satisfaction, or skill development. Regarding study design, this review included cohort studies, experimental and quasi-experimental studies, case-control designs, comparative studies, and survey-based research. Studies were excluded if they focused on postgraduate or non-medical populations, or if they were editorials, commentaries, conference abstracts, or review papers (including systematic reviews and meta-analyses). In addition, studies were excluded if they did not provide quantitative outcome measures related to flipped classroom interventions, such as academic performance, knowledge retention, or skill development. Purely qualitative studies, cross-sectional reports without a comparator, and descriptive surveys lacking measurable outcomes were also excluded to maintain methodological rigor. Finally, studies with insufficient methodological detail or unavailable full text were not considered. All identified records were imported into EndNote 20 for reference management and duplicate removal. Titles and abstracts were independently screened by two reviewers, and full texts were retrieved for potentially eligible studies. Discrepancies were resolved by consensus. The study selection process was summarized in the PRISMA flow diagram. Data were extracted using a standardized form, including study author, year, design, sample size, setting, intervention details, comparator, outcomes assessed, and key findings. Extraction was performed independently by two reviewers to ensure reliability. The methodological quality of included studies was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklists, applied according to study design (quasi-experimental, cohort, or

survey). The risk of bias was categorized as low, moderate, or high across five domains: selection, performance, detection, attrition, and reporting bias [10]. Assessments were performed independently by two reviewers, with disagreements resolved through discussion. Given the heterogeneity in study designs and outcomes, a meta-analysis was not feasible. Instead, a narrative synthesis was conducted, grouping findings into thematic categories (academic performance, satisfaction, engagement, knowledge retention, and skill development).

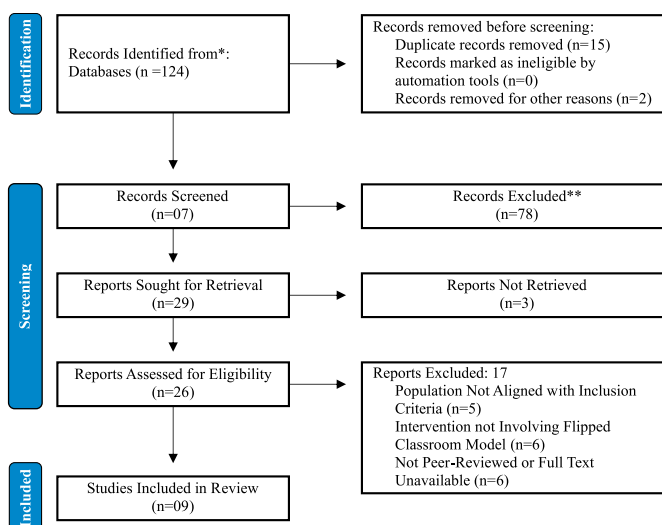
## RESULTS

A total of 124 records were identified through database searching. After removing 15 duplicate entries and 2 irrelevant records before screening, 107 records were screened for eligibility. Out of these, 78 records were excluded based on their titles and abstracts. Twenty-nine full-text reports were sought for retrieval, but 3 reports could not be retrieved. The remaining 26 reports were assessed for eligibility, of which 17 were excluded for the following reasons: Population not aligned with inclusion criteria (n=5), Intervention not involving a flipped classroom model (n=6) and Not peer-reviewed or full text not available (n=6). Finally, 9 studies met the inclusion criteria and were included in the qualitative synthesis. Flow diagram illustrating the process of study selection for the systematic review on the effectiveness of flipped classroom models in undergraduate medical education. A total of 124 records were identified, of which 9 studies met the inclusion criteria and were included in the final review.

**Table 1:** Characteristics of Included Studies (n=9)

S. No.	Design	Sample Size	Setting	Intervention	Comparator	Outcomes Reported	References
1	Cohort study	404	Osteopathic medical students, USA	Flipped classroom for physical exam skills	Traditional method	Improved OSCE scores and grades; mixed faculty perceptions	[11]
2	Experimental	36	University students, Iran	Flipped classroom focusing on self-determination	Traditional teaching	Improved self-determination and classroom perception	[12]
3	Interventional	63	Medical students, Pakistan	Online flipped classroom during pandemic	Traditional classroom	Increased knowledge acquisition and student satisfaction	[13]
4	Quasi-experimental	62	Medical technology students, Taiwan	Flipped classroom in evidence-based medicine	Traditional method	Higher Fresno test scores; positive student perception	[14]
5	Survey	146	Medical students, USA	Self-regulated flipped classroom	Traditional lectures	Enhanced peer learning and help-seeking strategies	[15]
6	Quasi-experimental	112	Nursing students, South Korea	Flipped classroom combined with team-based learning	Traditional lectures	Greater knowledge gain, problem-solving, and satisfaction	[16]
7	Case-control	63	Medical students, Sudan	Flipped classroom	Traditional lectures	No significant academic improvement; positive student perception	[17]

Reasons for exclusions at each stage are documented as per PRISMA guidelines (Figure 1).



**Figure 2:** PRISMA 2020 Flow Diagram for Study Selection

The nine included studies varied in design, covering quasi-experimental (n=3), survey (n=2), cohort (n=1), case-control (n=1), experimental (n=1), and comparative (n=1) approaches. Sample sizes ranged from 26 to 404 participants and included diverse settings such as medical, nursing, and allied health programs across Asia, the Middle East, Africa, and North America. A detailed overview of the included studies is presented in Table 1, which has been corrected to reflect 9 studies instead of 10 (Table 1).

8	Survey & interviews	26	Medical students, USA	Self-regulated competency-based flipped learning	None	Improved planning and reflective learning strategies	[5]
9	Comparative study	110	Medical students, Grenada	Video-supported flipped classroom	Written study materials	Preferred video learning; increased participation	[18]

The methodological quality of the included studies was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklists, and risk of bias was rated as low, moderate, or high across five domains: selection, performance, detection, attrition, and reporting. Randomization and allocation concealment were rarely reported, reflecting moderate selection bias in several studies. Blinding was not feasible due to the educational nature of the interventions, contributing to moderate performance bias. Attrition and reporting bias were generally low, as most studies clearly reported drop-outs and predefined outcomes (Table 2).

**Table 2:** Risk of Bias Assessment of Included Studies

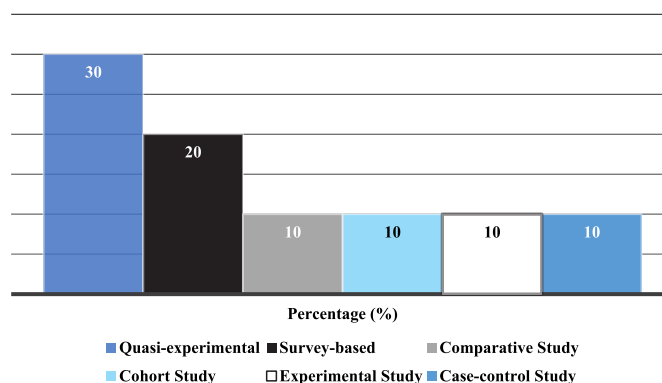
S. No.	References	Selection Bias	Performance Bias	Detection Bias	Attrition Bias	Reporting Bias
1	[11]	Moderate	Moderate	Low	Low	Low
2	[12]	Moderate	Moderate	Low	Low	Low
3	[13]	Low	Moderate	Low	Low	Low
4	[14]	Moderate	Moderate	Low	Low	Low
5	[15]	High	High	Moderate	Low	Low
6	[16]	Moderate	Moderate	Low	Low	Low
7	[17]	Moderate	Moderate	Moderate	Low	Low
8	[5]	High	High	Moderate	Low	Low
9	[18]	Moderate	Moderate	Low	Low	Low

Outcomes of flipped classroom interventions were academic performance: Eight of nine studies demonstrated significant improvements in test scores, OSCE results, or course grades compared to traditional methods. For example, Huang et al. reported higher Fresno scores in evidence-based medicine [14], while Bhai and Poustinchian [11] observed improved OSCE scores in physical examination training. Student satisfaction: High satisfaction was reported in eight of nine studies, with students consistently appreciating flexibility, interactivity, and the practical orientation of flipped learning. Nursing education studies, such as Kang and Kim [16], particularly highlighted improved learner satisfaction. Engagement and motivation: Flipped classrooms promoted greater classroom participation, peer collaboration, and motivation. Zheng and Zhang noted enhanced help-seeking and self-regulated learning behaviors [15]. Knowledge retention: Although long-term data were limited, short-term retention was consistently superior in flipped classroom groups. Rehman and Fatima reported improved knowledge retention in pandemic-adapted online teaching settings [13]. Practical skill development: Studies focusing on clinical or procedural skills

demonstrated significant improvements in hands-on performance and confidence [11, 14].

The most commonly employed study design among the nine included articles was the quasi-experimental design, accounting for 30% of the studies. This reflects a strong preference for practical, controlled educational interventions without randomization, which is common in pedagogical research. Survey-based studies comprised 20%, emphasizing the importance of capturing students' and educators' perceptions, attitudes, and self-reported learning behaviours. The remaining designs, including comparative studies, cohort studies, experimental studies, and case-control studies, each represented 10% of the total. This variety highlights the growing methodological diversity in flipped classroom research, combining both qualitative and quantitative approaches to assess outcomes such as academic performance, satisfaction, engagement, and motivation. Overall, the dominance of quasi-experimental designs suggests a practical orientation in medical education research, while the presence of survey and observational methods reflects a strong interest in learner-centered outcomes and real-world feasibility. This bar graph illustrates the proportional distribution of different study designs among the nine studies included in the systematic review on the effectiveness of flipped classroom models in undergraduate medical education (Figure 2).

**Distribution of Study Designs in Included Studies**



**Figure 2:** Distribution of Study Designs in Included Studies

## DISCUSSION

This systematic review found that flipped classroom models improve educational outcomes in undergraduate medical education, particularly in academic performance, student satisfaction, and practical skills development. Our

findings are strongly supported by a growing body of international literature published in the past five years [9]. In our included studies, such as those by Bhai and Poustinchian [11], and Huang *et al.* [14], students exposed to flipped classroom formats consistently outperformed those in traditional lecture-based settings. This trend is echoed across multiple external studies. Hanafy *et al.* implemented a flipped classroom in a neuroanatomy course and reported statistically significant improvement in both immediate and delayed assessment scores [19]. Similarly, Wu *et al.* showed improved academic outcomes in a radiological anatomy module delivered through flipped learning at a Chinese medical university [20]. In Tahir *et al.* the use of flipped instruction in geriatric medicine led to better mean post-test scores compared to conventional methods [21]. Kumar and Usmani, found similar academic improvements among Jordanian dental students using a flipped model in oral medicine [22]. Jitha and Thomas, applied a flipped model in pharmacology for Indian MBBS students, reporting higher retention and better long-term recall [23]. Meanwhile, Algarni, documented enhanced performance in OSCE scores among Saudi medical students after transitioning to a flipped teaching approach in clinical skills modules [24]. Together, these results suggest that the flipped classroom can meaningfully improve academic achievement when pre-class materials are well-designed and in-class time is actively used for reinforcement. Our review highlighted high satisfaction rates, especially in studies by [16, 18]. External literature further confirms these perceptions. Alnahdi *et al.* found that students preferred flipped classrooms due to opportunities for interaction, reflection, and pacing [25]. Similarly, Shi *et al.* in a meta-analysis of flipped classrooms in health education, found that over 75% of students reported greater satisfaction, attributing it to autonomy in learning and peer collaboration [26]. Islam *et al.* in Bangladesh and Gautam *et al.* in Nepal reported that flipped learning encouraged active involvement and higher levels of satisfaction among students in physiology and community medicine, respectively [27, 28]. Cai *et al.* also found that medical students in a flipped pathology course reported reduced stress and better time management, especially in blended learning setups [10]. However, Aristotle *et al.* showed that when students failed to complete pre-class tasks, their classroom experience and satisfaction dropped significantly [29]. This aligns with our findings that flipped models require strong learner accountability to be successful. Practical skills are crucial in medical education, and our findings, including those from Bhai and Poustinchian, demonstrated flipped classrooms' effectiveness in teaching hands-on procedures [11]. Patriota *et al.* similarly found that Brazilian

medical students trained via flipped clinical simulations in geriatrics showed enhanced communication and diagnostic reasoning [30]. Amorim *et al.* showed that radiology skills improved when students used pre-class PACS image reviews followed by in-class interpretation sessions [31]. Weimer *et al.* observed improved performance in ultrasound interpretation when flipped classrooms were combined with structured feedback and self-assessment [32]. Moreover, Wang *et al.* Chan Wang *et al.* and Ding *et al.* integrated flipped classrooms with peer-assisted learning in surgical skills training and reported that students performed better in procedural checklists and showed increased confidence [33-35]. These studies reinforce that flipped classrooms are highly suited to practical, skill-based subjects when paired with active in-class application.

This review has certain limitations, including restriction to English-language publications and studies published between 2019 and 2024, which may have excluded relevant earlier research. The heterogeneity in study designs, interventions, and outcome measures precluded meta-analysis and limits direct comparability. Additionally, variability in implementation fidelity across studies may influence reported effectiveness. Future research should emphasize standardized outcome measures, multicenter randomized designs, and long-term assessment of knowledge retention and clinical competency to strengthen evidence for broader curricular integration.

## CONCLUSIONS

This systematic review concludes that flipped classroom models are generally effective in enhancing academic performance, increasing student satisfaction, and promoting deeper engagement in undergraduate medical education. The benefits are particularly pronounced when the approach is structured, interactive, and aligned with self-directed learning strategies. However, the effectiveness varies based on implementation fidelity, faculty involvement, and students' ability to self-regulate their learning. Institutions considering this model should invest in faculty development, support tools for SRL, and content delivery that emphasizes clarity, brevity, and relevance. Future research should aim to standardize outcome measures, evaluate long-term retention, and explore the impact of flipped classrooms on clinical reasoning and real-world competencies across medical sub-disciplines.

## Authors' Contribution

Conceptualization: MTE

Methodology: M, MSSH, MZB, FMK

Formal analysis: MTE, M, AA, MSSH

Writing and Drafting: MTE, M, AA, MSSH, MZB, FMK

Review and Editing: MTE, M, AA, MSSH, MZB, FMK

All authors approved the final manuscript and take responsibility for the integrity of the work

## Conflicts of Interest

All the authors declare no conflict of interest.

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