

*Original Research Article*

# Flipped Learning Outcomes among Undergraduate Medical Students, Systematic Review and Met analysis, 2022

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Abstract

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The "flipped classroom" method is a promising educational breakthrough for application in medical education. Team-, problem-, and case-based learning models have manifested as a result of the drivers of student-centered learning. Even though there has been a shift toward the flipped classroom, relatively little is known about its use in nursing courses. This systematic review sought to explore how the flipped classroom has been used in medical education and the outcomes associated with this method of instruction. A search of four databases yielded the 3944 retrieved records from four electronic databases: PubMed, Web of Science, Scopus, and the Cochrane Library, from the 1<sup>st</sup> to the 20<sup>th</sup> of October 2022. After the title and abstract screening process for inclusion and exclusion criteria, each paper was reviewed with a critical evaluation instrument. All of the studies that were included had their data extracted. Only 26 of the studies were eligible for screening and analysis. All writers evaluated the quality of the included research rigorously. There were ten studies found, and the common themes were how well students did in school and how happy they were with the flipped classroom. In undergraduate medical education, using the flipped classroom compared to other traditional teaching methods had neutral or positive effects on students' grades and positive and promising effects on their satisfaction. Further studies are still required.

**Keywords:** Flipped learning, Medical students, Outcomes, Undergraduates

## INTRODUCTION

The "flipped classroom" method is a promising educational breakthrough for application in medical education (Moffett, 2015). It is an approach in which knowledge gained from online content is applied before face-to-face learning while the core teaching is delivered utilizing online material (Chowdhury et al., 2019).

A typical flipped (pre-class learning) is typically done in a variety of methods in a flipped classroom, including: Reading assignments include textbooks, instructor-created materials, handouts, guided readings, primary literature, and online modules, simulations, and learning

aids.; Video lectures round out the list of reading assignments (lecture recordings, PowerPoint slides with voiceover, and podcasts) learn the material before class (Han and Klein, 2019).

Consequently, even though there are alternative ways to implement flipped classrooms, classes can now participate in more engaging educational activities, such as group discussions, that provide students with a comprehensive understanding of the subject. Having more time to solve problems and making better use of class time for facilitation are the two main objectives of the flipped classroom paradigm. As a result, there is

enough time for group discussions and activities, boosting student and teacher connections. Student engagement is one of the finest measures of learning and personal growth, according to Carini et al. A learner typically learns more about a subject the more they study or practice it (Chen et al., 2017; Carini et al., 2006). Demand is a powerful motivator for users (Lo, 2017; Lo and Hew, 2017).

One of the major challenges facing medical educators is delivering medical education materials in fewer hours with a reduction of different courses in the integrated comprehensive curricula. The flipped classroom modality may be an innovative solution. However, its effectiveness remains under debate due to a lack of outcome-based research and the mixed results of students' performance (Abir El Sadik and Waleed, 2020). Numerous studies on the flipped (or inverted) classroom approach have been published in recent years (Chen and Chen, 2018)

So this study is based on my experiences and reflections on systematic reviews of research on flipped classrooms in several contexts. The study analyzes the contributions of systematic reviews to the field of flipped learning outcomes among undergraduate medical students. In contrast to a number of previously published reviews, this article discusses practical components of systematic reviews, such as literature search, article selection, and study synthesis. A summary finishes the chapter.

## METHODS

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement guidelines. (Page et al., 2021) and performed all steps based on the Cochrane Handbook of Systematic Reviews of Intervention (Higgins et al., 2016).

### Search strategy

First, we conducted a limited search on PubMed to identify and analyze relevant key words and index terms. Second, we searched through four electronic databases; PubMed, Cochrane Library, Web of Science, and Scopus from the 1<sup>st</sup> to the 20<sup>th</sup> of October 2022. There was no restriction on the year of publication. But, only articles in English were included.

### Study selection criteria

Studies were included according to the PICOS strategy. We included studies with (1) population: undergraduate medical students; (2) intervention: flipped learning; (3) control: traditional learning; (4) outcomes: effect of flipped

learning on students' performance or perception; and (5) study design: any comparator clinical studies.

Non-comparator observational studies, case reports, case series, conference abstracts, and studies lacking a relevant population, intervention, or outcomes were all excluded.

### Screening and quality assessment

Three review authors independently screened titles and abstracts of the records retrieved according to the search strategy to identify any article that potentially meets the inclusion criteria outlined above. The same review authors independently assessed the full text of the selected studies for eligibility. If they couldn't agree on whether a study was eligible, they talked about it or asked a senior reviewer for help.

The risk of bias in included studies was assessed independently by two authors using the National Institutes of Health (NIH) quality assessment tool for controlled intervention and observational cohort studies. Any disagreement was resolved by discussion with the supervisor of our study. This tool includes 14 questions that can be answered with "yes", "no" or "can't determine". Every "yes" presented counts as 1 point in the total score. Each study was rated as poor (0–5), fair (6–10), or good quality (11–14) (National Heart, Lung and Blood Institute).

### Data extraction

Two authors extracted the data using a formatted excel sheet for data extraction. Any disagreement was resolved through discussion or with a senior reviewer. The extracted data included the following: A summary of the articles includes the design, sample size, population, setting, and main findings.

### Data synthesis

We analyzed the scores of students in terms of mean difference and standard error. The analysis was conducted using Open Meta Analyst software for Windows (Meta-Analyst, 2018). For analysis, we used the random-effects model (DerSimonian-Laird methods). Data was pooled as a standardized mean difference (SMD) with a 95% confidence interval (CI). We considered data statistically significant if the p-value was 0.05. Statistical heterogeneity between studies was measured by the Chi-square and I-squared tests for heterogeneity (McHugh, 2013). If the p value was less than 0.05, we considered the data statistically heterogeneous.

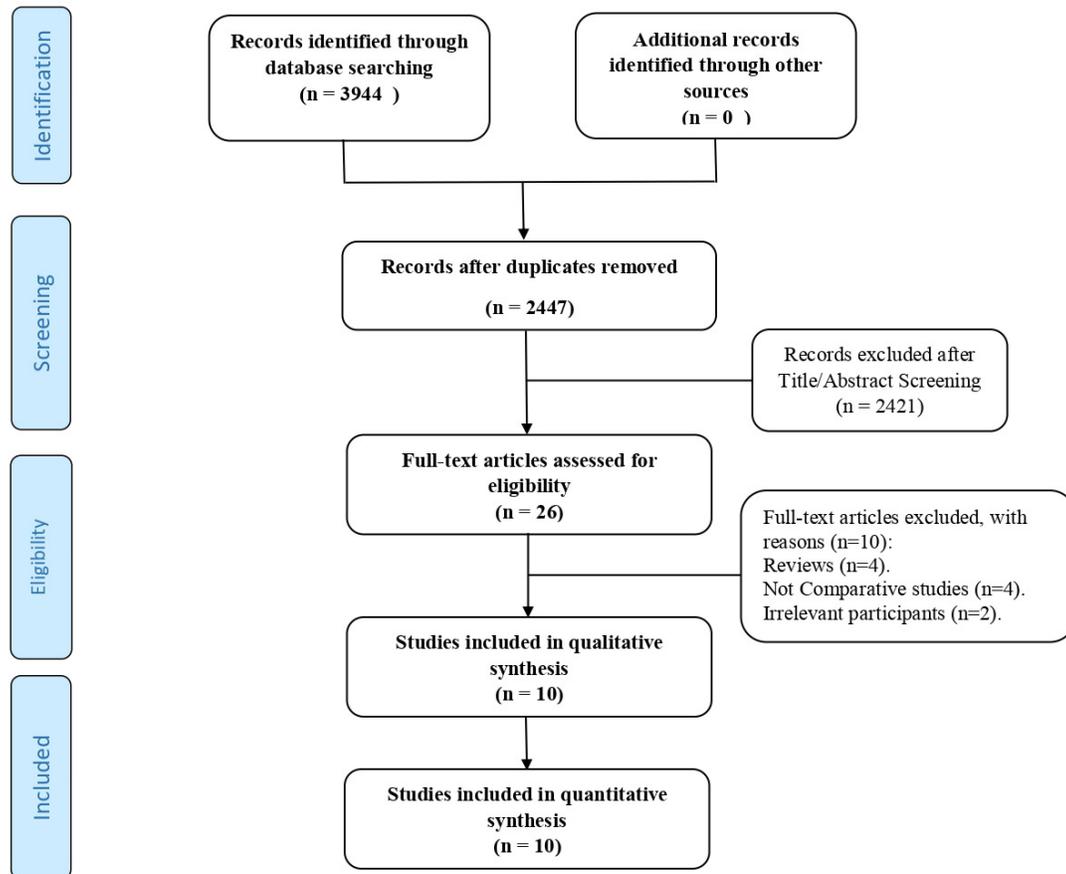


Figure 1. PRISMA Flow Chart

## RESULTS

Our search retrieved 3944 records from four electronic databases: PubMed, Web of Science, Scopus, and the Cochrane Library. After duplication removal and the title and abstract screening process, only 26 studies were eligible for full-text screening. We excluded any study that was not comparative or not available in English. Finally, ten of them were included in the quantitative synthesis. Figure 1 represents the PRISMA flow chart of the selection process.

All the included studies are of a comparative design. Most of them are randomized, controlled, or experimental trials. Shahba 2022 was a cross-over study, while Elzainy 2022 was a pilot study with a mixed methods design (Elzainy and El Sadik, 2022; Shahba et al., 2022). All of them were conducted between 2017 and 2022. This review has a total sample size of 1618 participants, who were undergraduate university students. Table 1 represents a summary of the included studies.

We assessed the included articles using the National Institutes of Health (NIH) tool for quality assessment of controlled studies (National Heart, Lung and Blood Institute (NHLBI)). Most of them were of fair quality. Only

Qutieshat et al., 2021 (17) were poor, and Golaki et al., 2022 (18) were of good quality. Table 2 represents the quality assessment of the included studies.

### Students' performance or test scores

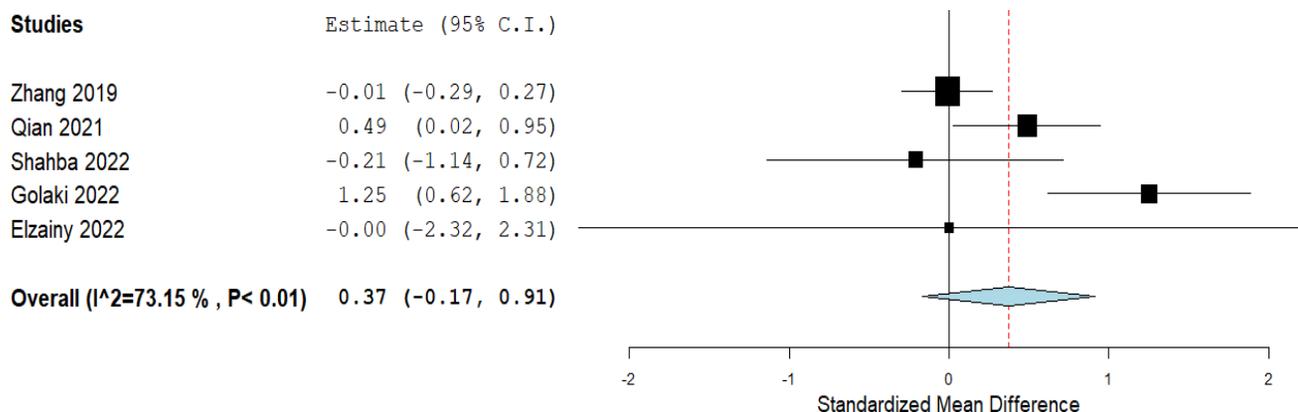
We categorized the included studies into a first group that included pre and post-learning assessments and a second group that included only post-learning assessments. We conducted the meta-analysis based on that. The effect estimate of group one shows superiority in favor of flipped learning over traditional one (SMD 0.37, 95% CI [0.17, 0.91],  $p = 0.18$ ). Pooled studies were heterogeneous ( $P = 0.01$ ,  $I^2 = 73.15\%$ ) (Figure 2). Heterogeneity was best resolved by the exclusion of Golaki et al. 2022 (18) ( $P = 0.29$ ,  $I^2 = 19.18\%$ ). In the second group, the overall effect estimates favored flipped learning over traditional learning (SMD 0.84, 95% CI [0.55, 1.13],  $p = 0.01$ ). Pooled studies were heterogeneous ( $P = 0.01$ ,  $I^2 = 78.1\%$ ) (Figure 3). After excluding Kong 2020 and Angadi 2019 (19,20), the detected heterogeneity was best resolved ( $p = 0.22$ ,  $I^2 =$

Table 1. Represents a summary of the included studies

Study ID	Setting	Study Design	Total Sample Size	Population	Intervention group	Comparison group	Educational Content	Main Findings
Zhang 2019	China	Randomized Controlled Trial	197 (115/82)	2nd year Clinical undergraduate students of Kunming Medical University	A flipped classroom based on SPOC	Lecture-based learning (LBL)	Physiology course	The classroom activities in both the LBL control and SPOC groups improved learning, but there was an additional enhancement associated with the SPOC video preview in the experiment group.
Kong 2020 [19]	China	Experimental comparative Study	248 (125/123)	Undergraduate students at the School of Medical Technology, Beihua University	A flipped classroom	Nonflipped Traditional Learning	Medical molecular biology	FC method causes a statistically considerable improvement in learning and learning experiences in medical molecular biology.
Qian 2021	China	Prospective, controlled educational research study	74 (37/37)	Undergraduate medical students of Shanghai University of Medicine and Health Sciences	A flipped classroom with micro-lessons	A face-to-face traditional lecture	Educational content about COVID-19	A flipped classroom based on micro-learning combined with CBL showed greater effectiveness in COVID-19 knowledge gain and made their attitude toward clinical practice more positive.
Shahba 2022	Saudi Arabia	Pilot study that utilized a mixed methods design	18 (9/9)	(Level 10, Bachelor's degree (B. Pharm), Male campus) College of Pharmacy at KSU	Interactive-electronic learning method (flipped learning)	Paper-based learning method	The Pharmaceutical Quality Control and GMP course (tutorials)	The remote interactive flipped e-learning (iFEEL) shows promising potential to be incorporated into online learning activities.
Angadi 2019 [20]	India	Interventional controlled educational research study	98 (49/49)	2nd year medical undergraduate students in the pharmacology department of a medical college	Flipped class	Conventional small group teaching group	Drugs acting on Cardiovascular System" (CVS) from pharmacology curriculum.	Medical teaching with flipped classroom approach improved the student performance and learning experience effectively as compared to conventional SGT.
Qutieshat 2021 [17]	Jordan	Experimental comparative study	617 (253/364)	Fourth-year dental students at Jordan University of Science and Technology	Flipped classroom	Conventional lectures in the classroom	The conservative dentistry course	The blended learning cohort had significantly higher scores on all course assessments than the conventional cohort.
El Sadik 2020 [24]	Saudi Arabia	Experimental comparative study	95 (46/49)	The first-year female students of Qassim Medical College	Flipped Anatomy Classrooms	Traditional Anatomy Classrooms	The musculoskeletal system module	This study adds to the literature that investigates the impact of a flipped classroom. It emphasizes its influence on Qassim medical students' performance, specifically in the gross anatomy classrooms.
Zhang 2022	China	Randomized Controlled Trial	79 (37/42)	Medical interns	Flipped classroom and OSCE	Traditional classroom and OSCE	Multiple clinical skills training	The FC model may be a better choice for teaching clinical skills to medical interns.
Golaki 2022	Iran	Randomized Controlled Trial	92 (46/46)	Nursing and midwifery students enrolled from Bushehr nursing and midwifery school	Flipped Classroom by Near Peer Education	Conventional Method	Basic concepts of patient safety, types of medical errors, and risk management	The use of the FC through NPE could increase the PSKRE mean scores and thus boost learning, but, in general, it had no effect on knowledge retention associated with PS in nursing and midwifery students.
Elzainy 2022	Saudi Arabia	Cross-over comparative Study	100	First-year male medical students aged 18–20 years of the College of Medicine, Qassim University	Eight lectures with Flipped modality	Eight lectures with Traditional modality	Musculoskeletal (MSK) system block	The implementation of the FC enhanced the students' achievement and attitude. This improvement was a driving force for its implementation of the FC in teaching anatomy as well as the other disciplines.

**Table 2.** Shows the perception of undergraduate medical students regarding different teaching methods

Study ID	Perception
Kong 2020 [19]	Student perceptions of the course and the FC teaching method were greatly favorable overall. In total, 97.6% of students agreed or strongly agreed with the statement, 'The FC model increased group collaboration with my instructor and classmates more than did the TL model.' In response to the item 'In the future, would you rather take a flipped course than a traditional course', 84.8% of students agreed or strongly agreed
Qian 2021	NA
Shahba 2022[15]	Student perceptions of the iFEEL activity were more favorable than the PICKLE activity. A significant improvement in students' acceptance of flipped learning. Most students (78.5%) preferred the feel over the PICKLE for future course offerings.
Angadi 2019 [20]	82 % strongly agreed that FC was more engaging and interesting in comparison to the traditional class. 76 % strongly agreed that more such classes should be conducted in the future.
Qutieshat 2021[17]	Overall, students' perceptions were positive and supported the adoption of a blended learning model in the course.
El Sadik 2020 [24]	40 % of the students reported that the flipped classroom was a very interesting learning style, which made them more committed and attentive in the class and allowed them to be engaged in the learning-teaching process. Perception surveys also revealed students' enthusiasm for the pre-class activities, leading to better performance in the class with more engagement with their peers and teachers.
Zhang 2022	NA
Golaki 2022	NA
Elzainy 2022[14]	The students' reflected their interest in practicing the flipped classroom, positive attitude towards the in-class activities, and a high level of interaction with their teacher and peers.



**Figure 2.** A Forest Plot of the meta-analysis pre and post-performance of the students.

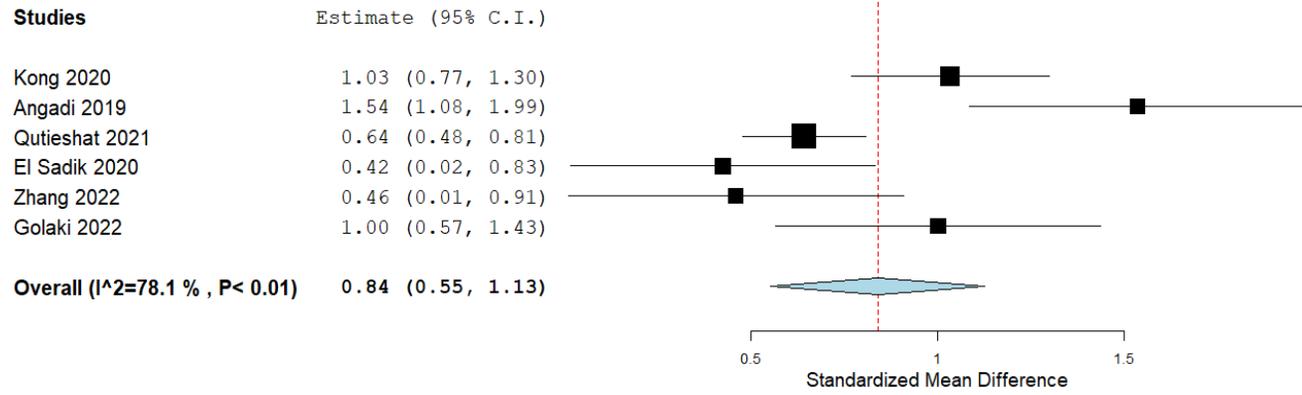


Figure 3. A Forest Plot of the meta-analysis post-performance scores of the students.

**Table 3.** Represents the quality assessment of the included studies.

For Controlled Intervention Studies	Zhang et al. 2019	Kong et al. 2020	Qian et al. 2021	Shahba et.al 2022	Angadi et.al 2019	Qutieshat et.al 2021	El Sadik et.al 2021	Zhang et.al 2021	Elzainy et.al 2022	Golaki et.al 2022	Yes F(%)
Was the study described as randomized, a randomized trial, a randomized clinical trial, or an RCT?	Yes	No	Yes	No	Yes	No	No	Yes	No	Yes	5(50.0%)
Was the method of randomization adequate?	NR	NA	Yes	NA	Yes	NA	NA	Yes	NA	Yes	4(40.0)
Was the treatment allocation concealed?	Yes	NR	NR	NR	NR	NR	NR	NR	NR	Yes	2(20.0)
Were study participants and providers blinded to treatment group assignment?	No	NR	NR	NR	NR	NR	NR	NR	NR	Yes	1(10.0)
Were the people assessing the outcomes blinded to the participants' group assignments?	No	NR	NR	NR	NR	NR	NR	NR	NR	NR	0(0.0)
Were the groups similar at baseline on important characteristics that could affect outcomes?	Yes	Yes	Yes	Yes	NR	Yes	Yes	Yes	Yes	Yes	9(90.0)
Was the overall drop-out rate from the study at endpoint 20% or lower of the number allocated to treatment?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10(100.0)
Was the differential drop-out rate (between treatment groups) at endpoint 15 percentage points or lower?	Yes	Yes	Yes	Yes	Yes	NR	Yes	Yes	Yes	Yes	9(90.0)
Was there high adherence to the intervention protocols for each treatment group?	NA	NA	NA	NA	NA	NA	NA	NA	NA	Yes	1(10.0)
Were other interventions avoided or similar in the groups?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10(100.0)
Were outcomes assessed using valid and reliable measures, implemented consistently across all study participants?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10(100.0)
Did the authors report that the sample size was sufficiently large to be able to detect a difference in the main outcome between groups with at least 80% power?	NR	NR	NR	NR	NR	NR	NR	NR	NR	No	0(0.0)
Were outcomes reported or subgroups analyzed prespecified?	No	No	Yes	Yes	Yes	No	NR	Yes	NR	Yes	5(50.0)
Were all randomized participants analyzed in the group to which they were originally assigned?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10(100.0)
<b>Overall Appraisal</b>	<b>Fair</b>	<b>Fair</b>	<b>Fair</b>	<b>Fair</b>	<b>Fair</b>	<b>Poor</b>	<b>Fair</b>	<b>Fair</b>	<b>Fair</b>	<b>Good</b>	<b>Good 1(10.0) Fair 8(80.0) Poor 1(10.0)</b>

As regards the quality assessment of **For Controlled Intervention Studies**, the following domains were the lowest The 0(0.0%) Did the authors report that the sample size was sufficiently large to be able to detect a difference in the main outcome between groups with at least 80% power?, 1(10.0%) Was there high adherence to the intervention protocols for each treatment group?. 1(10.0%) Were study participants and providers blinded to treatment group assignment?, 2(20.0%) Was the treatment allocation concealed?

31.1%). The finding of the statistical analysis is still significant ( $p = 0.01$ ).

### Students' perception of flipped learning

Out of the 10 qualitative studies, only six discussed the perceptions of undergraduate medical students regarding different teaching methods; 6/6 (100%) reported a favorable and positive attitude regarding the pre-class activities. (Table 3)

Compared to the TL model, the FC model increased group collaboration with my instructor and classmates (19), and the iFEEL activity was preferred over the PICKLE activity (Shahba et al., 2022). 84.8 percent of students agreed or strongly agreed that flipped courses are preferable to traditional learning (Kong et al., 2020; Angadi et al., 2019), and 78.5 percent chose the feel over the PICKLE for future course offerings (Shahba et al., 2022). 40% of FC learning was highly interesting, with a high level of interactions (Abir El Sadik and Waleed, 2020); 82% stated that FC was more engaging and entertaining than TL (Angadi et al., 2019); a good attitude (Qutieshat et al., 2020; Abir El Sadik and Waleed, 2020).

We could not assess publication bias in the current review because of the small number of included studies, according to Egger et al. (1997). As regards the overall appraisal, we reported only 1 (10.0%) by Golaki et al. (2022) of good appraisal, only 1 (10.0%) by Qutieshat et al. (2021), and the remaining of fair appraisal.

## DISCUSSION

In the modern era, there is no one-size-fits-all method for teaching medical underground students a certain concept. Visual, aural, read-and-write, and kinesthetic learning methods have been proven to vary dramatically across students (Samarkoon et al., 2013).

The flipped classroom paradigm permits the instructor to employ a variety of instructional tactics. This allows all types of students to learn and comprehend a medical topic. One of our goals in implementing the flipped classroom approach was to use class time to teach medical and examination facilitation skills so that students could use their theoretical knowledge during family visits (Sabale and Chowdary, 2019).

### As regards the effect of the FC compared to TL models

According to this meta-analysis, the effect estimate for group one indicates that flipped learning is preferable to traditional learning (SMD 0.37, 95% CI [0.17, 0.91],  $p = 0.18$ ). In the second group, flipped learning was preferred to traditional learning according to the overall effect

estimates (SMD 0.84, 95% CI [0.55, 1.13],  $p = 0.01$ ). The result of the statistical analysis is still significant ( $p = 0.01$ ), even after the heterogeneity has been resolved. This may be due to the fact that in flipped learning, students are not embarrassed to pause or replay the instructor's video lecture presentation; through these features, students can gain a deeper understanding of course subjects before moving on to new ones. Additionally, because they are not engaged in direct lecturing, teachers are better able to communicate with each student in the classroom. offer both one-on-one tutoring and tutoring in small groups during class meetings, instead of just giving lectures (Abeysekera and Dawson, 2015; Bergmann and Sams, 2008).

In the present investigation, we obtained comparable results: the FC model increased group collaboration with my instructor and classmates (Kong et al., 2020) compared to the TL model, and the iFEEL activity was favored over the PICKLE activity (Shahba et al., 2022). According to the AMEE Guide (Kennedy, 2019), advantages of the flipped classroom include increased student involvement, a shift from passive listening to active learning, collaborative student work, an increase in student-teacher engagement, a transfer of responsibility for learning to the students, and the ability to arrive to class well-prepared for success with this method. and the flexibility for students to prepare at a time that is convenient for them.

### As regards the undergrad medical students' perception of the FC

As a result of the abovementioned advantages, we reported that 84.8 percent of students agreed or strongly agreed that flipped courses are preferable to traditional learning (Kong et al., 2020; Angadi et al., 2019), 78.5 percent chose the feel over the PICKLE for future course offerings (Shahba et al., 2022), and 82% stated that FC was more engaging and entertaining than TL (Angadi et al., 2019); a good attitude (Qutieshat et al., 2020; Abir El Sadik and Waleed, 2020). The practical examination scores of students who participated in all activities were clearly higher. This is supported by the fact that 96% of the students believed it helped them apply their knowledge in the real world.

In this meta-analysis, the qualitative studies reported that about 40% of undergraduate medical students reported that FC learning was highly interesting, with a high level of interaction (Abir El Sadik and Waleed, 2020). This can be attributed to the Possible drawbacks include the need to spend time and money making courses, the possibility of needing to buy new technology, and the need for both teachers and students to change and learn the new skills that this more active and self-directed way of learning requires (Sabale and Chowdary, 2019).

## As regards the quality assessment

In light of this, because research had already been done on the flipped classroom, we were able to use the NIH quality assessment frameworks as a starting point for our analysis of outcomes and how people felt about them. This meta-analysis explores potential ways for enhancing the quality of systematic reviews. We read all of the texts, focusing in particular on the results, findings, and discussion sections. One of our research objectives was to determine how the flipped classroom method benefits medical student learning as well as the perceptions of flipping mathematics courses.

Existing frameworks assisted our study's synthesis despite the large amount of data that needed to be examined. And the majority of the controlled studies were of fair quality (80.0%). The main causes of this fairness were related to: 1) The authors report that the sample size was sufficiently large to be able to detect a difference in the main outcome between groups with at least 80% power. 2) Was there high adherence to the intervention protocols for each treatment group? 3) Were study participants and providers blinded to treatment group assignment? 4) Was the treatment allocation concealed?

Finally, The rise in the number of literature review studies reflects the increase in research on flipped classrooms. The majority of these are systematic reviews (Karabulut et al., 2018; Ramnanan and Pound, 2017; Lundin et al., 2018). If the scope of reviews has remained the same, one would expect these modern reviews to include and evaluate more research items than past reviews. Moreover, because flipped classroom practice is becoming increasingly innovative (e.g., gamified flipped classroom), current reviews must provide novel insights for future research and practice. However, this is not always the case.

## Strength

This framework included essentially aspects of operating a flipped classroom among undergraduate medical students. This study established three types of aspects in their systematic evaluation of flipped medical education, including (1) the performance outcomes among the undergraduate medical students compared to the TL, (2) their perceptions of and attitudes towards the FC, and (3) the overall quality assessment of the published controlled interventional studies that used the implementation of flipped classrooms as an example.

## limitations

We could not assess publication bias in the current review because of the small number of included

studies. Moreover, The definition of the "flipped classroom" approach was added as a challenging selection criterion to our systematic reviews. My understanding of "inverting the classroom" is that events that have traditionally occurred within the classroom are now occurring outside of it, and vice versa.

## CONCLUSION

In undergraduate medical education, the use of the flipped classroom generated neutral or positive academic outcomes and promised positive results for student satisfaction. Academics engaged students in the flipped classroom model by informing and justifying the objective of the flipped classroom model to students. However, this study did not identify any research that evaluated the process of implementing the flipped classroom. There is a need for research on the method, continuous review, and refinement of the flipped classroom in medical education.

## RECOMMENDATION

Based on our findings, we recommend

- FC should be recommended for undergraduate medical students.
- Further research on other learning modalities
- Using the roles of overall critical appraisal scores to improve the quality of interventional studies, especially when it comes to the following: 1) The authors report that the sample size was sufficiently large to be able to detect a difference in the main outcome between groups with at least 80% power. 2) Was there high adherence to the intervention protocols for each treatment group? 3) Were study participants and providers blinded to treatment group assignment? 4) Was the treatment allocation concealed?

## List of Abbreviations

- Standardized mean difference (SMD)
- Confidence interval (CI)
- The National Institutes of Health (NIH)
- Lecture-based learning (LBL)
- Flipped classroom(FC)
- Traditional Learning(TL)
- Interactive Flipped e-learning(iFEEL )
- Paper-based in-class group learning (PICKLE)

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### Consent to Publish

Written informed consent for publication was obtained from all authors.

### Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request (dr\_samar11@yahoo.com)

### Declarations of Interest

All authors declared that they have no interest.

### Competing interests

The authors declare that they have no competing interests.

### Funding

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### Conflict of Interest

The authors reported no potential conflict of interest.

### Transparency statement

I affirm that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

### Authors contribution

Conceptualization: Sameer Abdullah Softa (SS) and Samar Amer (SA)  
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Validation: MMA, MMB, and EE  
Formal analysis: MMA, MMB, and EE  
Data curation: MMA, MMB, and EE  
Writing—Preparation of the First Draft: SA and SS  
Writing, reviewing, and editing: all authors  
Visualization:SS  
Supervision: SS

Software: SA

Project administration: SA and SS

All authors have read and agreed to the published version of the manuscript.

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