Original article

Effectiveness of flipped classrooms in nursing education: Systematic review and meta-analysis

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ABSTRACT

Background: The flipped classroom has generated considerable interest in nursing education in the last few years, especially in higher education in China. However, research to date has been insufficient to confirm the effectiveness of the flipped classroom approach. Since most of the Chinese studies are published in Chinese journals, they may not be easily accessible to international researchers. Therefore, this meta-analysis aimed to review the effectiveness of a flipped classroom in nursing education both in English and Chinese databases.

Objective: The aim of the present study was to identify the robust available evidence about the effectiveness of flipped classrooms in nursing education through a systematic review and meta-analysis.

Methods: A systematic search of English databases, including PubMed, EMBASE, Science Director, CINAHL and Google Scholar, and Chinese databases, including Chinese National Knowledge Infrastructure (CNKI), WanFang Data, VIP Information and Chinese Biomedical Literature (CMB), were conducted to identify peer-reviewed studies that met the inclusion criteria. Two reviewers independently performed study identification with Endnote X7 software and used Excel to extract data. The risk of bias in the included studies was assessed with Cochrane Collaboration's risk of bias tool, and a meta-analysis was conducted using RevMan 5.3 software following the guidelines proposed by PRISMA reporting standards with the protocol register No. CRD42016041826.

Results: A total of 29 studies were included in systematic review. There was a significant post-intervention improvement in academic performance both in knowledge with a pooled random-effects standardized mean difference of 1.13 and skills with a pooled random-effects standardized mean difference (SMD) of 1.68. Students' self-learning abilities were also improved with a pooled random-effects SMD of 1.51 compared with traditional lecture. In the subgroup analysis, we found that the effect sizes had high fidelity in terms of nursing degrees and research settings. There was a high rating of flipped classroom pedagogy from teaching evaluations, study satisfaction, study attitude and improvement in critical thinking and problem-solving skills.

Conclusions: These results indicated that a flipped classroom might help nursing students improve in knowledge, skills, attitudes, self-learning, study satisfaction, critical thinking and problem-solving skills. We recommend adopting this approach for nursing education reform. There is a call for robust empirical research and unification of appraisal standards for further support of the effectiveness of the flipped classroom. Furthermore, a meta-regression analysis is also recommended to explore the sources of heterogeneity in included studies.

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1. Introduction

There is a gap between nursing education and actual practice such that newly graduated nursing students struggle to meet workplace requirements.¹ To address this gap, there has been a call for a radical transformation in nursing education involving educators designing learning experiences that enhance education...
quality and ensure that graduates are prepared for today's complex nursing practice at different health care facilities. New innovative teaching strategies are critical to integrate into nursing education. The literature tells us that one of the primary components of effective teaching is student engagement and that engagement is critical for learning. Reflecting this change is the rise in the flipped classroom that is an alternative pedagogy that shifts from traditional lectures to active learning and would offer opportunities to integrate clinical experiences within the classroom.

The flipped classroom is an instructional strategy that provides a new methodology and modality for teaching and learning. It involves a role change for instructors as a way of minimizing the amount of direct instruction in their teaching practice while maximizing one-to-one interaction and more cooperative and collaborative contribution to the teaching process, which can improve and encourage social interaction, teamwork and cultural diversity among students. The roles of students have a corresponding change from passive participants to active participants. The modern flipped classroom began in 2007 in a high school chemistry course in Colorado. It could be argued that the flipped classroom has been in existence within the broader educational sphere for a number of years. Flipped classrooms take what was previously class content and replace it with what was previously homework, which now takes place within the class. In addition, this approach fosters student ownership of learning through the completion of preparatory work and being more interactive during actual class time. Proponents of the flipped class suggest that this pedagogy allows students to learn at their own pace, and they may have flexibility as to when they engage with electronic resources. It frees up actual class time for robust discussion and associated problem-solving activities, which could be initiated by the students, not the staff member. This pedagogy may help students to improve self-ef
cacy through self studying, problem-solving and communication skills, which are skills that are recommended by the Institute of Medicine report from 2010.

Many studies have already reported that the flipped classroom had a positive effect on education outcomes, such as accelerating self-learning, improving academic performance, developing critical thinking skills, and increasing positive feedback. However, some of the studies also showed no significant differences in final exam scores between students undertaking traditional lectures and those in the flipped classroom and even had less satisfaction with the flipped class approach due to increasing the amount of out-of-class preparation time. Meanwhile, students and staff are reluctant to abandon the lecture-based approach because it requires little active student participation.

Despite acknowledgement of the positive attributes of the flipped classroom, few articles used a robust scientific method to verify educational outcomes as they relate to improved student learning and attitude. Rigorous experimental research on the flipped classroom in higher education is very limited. Other nurse scholars have conducted systematic reviews to address flipped classroom models in nursing education and found that a meta-analysis was impossible due to the limited number and heterogeneity of studies. Therefore, research to date is insufficient to confirm the effectiveness of the flipped classroom approach.

The flipped classroom has generated considerable interest in nursing education in recent years. Although experimental research on the flipped classroom published in English is limited, there has been a recent influx of empirical evidence on the flipped classroom in Chinese nursing education. Since Chinese articles may not be easily accessible to international researchers due to language barriers, this review aims to examine whether the flipped classroom is more effective than the traditional lecture through synthesizing both English and Chinese studies. The following research questions are addressed in this paper:

What effects of the flipped classroom compared with the traditional lecture have been reported in nursing education?

To what extent do the effects of flipped classrooms relate to knowledge, skills and attitudes compared with traditional lectures in nursing education?

What is the rating of self-report questionnaires as to the effectiveness of the flipped classroom?

2. Methods

We conducted this meta-analysis according to the guidelines proposed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards of quality for reporting this review.

2.1. Protocol and registration

This protocol was registered in PRISMA with register No. CRD42016041826 and is available from http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42016041826.

2.2. Inclusion and exclusion criteria

Studies were selected for inclusion if the study had (a) participants were in a higher education program including associate degree students, undergraduates, and postgraduates, (b) a randomized controlled trial design, (c) a flipped classroom approach in the intervention group, (d) traditional lectures in the control group, (e) measurable outcome indices, and (f) publication in Chinese and English. Exclusion criteria included that the study (a) was conducted with students in disciplines other than nursing or register nurses, (b) was a non-randomized controlled trial, (c) had an intervention that utilized flipped classroom and at the same time accepted other teaching methods, or (d) had non-extractable outcome data.

2.3. Data sources and searches

The English databases searched included PubMed, EMBASE, CINAHL, Google scholar, and the Chinese databases searched included CNKI, WanFang Data, VIP and CMB. We identified peer-reviewed studies in accordance with the inclusion criteria from inception to November 2016. To identify as many eligible studies as possible, we broadened search terms and strategies. Search terms were modified together with informatics and combined with Boolean operators as follows: ‘nurs*’ AND (‘flip* classroom’ OR ‘invert* classroom’ OR ‘revers* classroom’). The reference lists of the eligible articles included after the electronic search were also manually searched. Two researchers searched the databases together and independently selected the eligible articles. Articles with the same authors were included as long as the research participants were from different areas. Any discrepancies were resolved through discussion with the third researcher.

2.4. Data extraction process and quality assessment

Data extraction and article quality assessment were performed by two researchers independently. Disagreements were resolved by consensus. The following information from the studies was extracted based on a predesigned coding manual form: authors and years of publication, sample size, educational degrees, subjects, withdrawal rate, and intervention and outcome measures.
The quality of the included studies was based on the six general sources of bias described in the Cochrane Handbook for Systematic Reviews of Interventions. The following quality items were checked: adequacy of the generation of the allocation sequence, concealment of allocation, blinding procedures, incomplete outcome data, selective outcome reporting, and other sources of bias. These items were obtained from the published reports, and the authors were contacted if additional information was required. The methodological quality of these domains was assessed by using the following scoring: (1) ‘low risk of bias’, when plausible bias unlikely alters the results, (2) ‘unclear risk of bias’ when plausible bias raises some doubt about the results and (3) ‘high risk of bias’ when plausible bias seriously weakens confidence in the results.23

2.5. Statistical analyses

Review Manager 5.3 software24 was used to test the data for heterogeneity and to carry out the meta-analysis. As continuous data from different scales were extracted, the standardized mean difference (SMD) was calculated for effect size based on sample size25 and 95% confidence intervals for each study, and for the pooled studies using variance analysis. Weighted mean difference (WMD) and 95% confidence intervals (CI) were calculated for continuous data from the same scale. A two-sided P-value of less than 0.05 was regarded as significant for all analyses. There were two meta-analysis models. A fixed-effects model was used to pool data if there was no heterogeneity, and otherwise we used a random-effects model. Heterogeneity was considered significant for a P-value of Cochran’s Q statistic <0.1 or an \( I^2 > 50\% \).26 \( I^2 \) is the percentage of variation attributed to heterogeneity and is easily interpreted. An \( I^2 \) statistic of 25%–50% was considered low, 50%–75% was considered moderate, and >75% was considered high. If heterogeneity was found, we conducted a sensitivity analysis to assess if this heterogeneity significantly altered the results of the meta-analysis. We performed the sensitivity analysis by excluding studies one by one, and then recalculating the pooled estimates for the remaining studies. However, this process did not significantly alter the results. Subgroup analyses were planned according to pre-set variables, including educational degree and research setting. Publication bias was assessed through funnel plots, and funnel plots shapes did not reveal obvious evidence of asymmetry.

3. Results

3.1. Search results

The search yielded 497 relevant studies that were downloaded into EndNote X7. After the removal of duplicates, the 244 residual references were reviewed based on the title and abstract. Then, 73 full text studies were assessed for eligibility. Subsequently, a total of 29 eligible studies were included in the meta-analysis. Fig. 1 provided a flow chart illustrating our search strategy and output.

3.2. Characteristics of included studies

Twenty-nine articles9,10,12,27–52 were included in this review. They were all Chinese articles published from 2014 to 2016. Sixteen studies measured theoretical examination scores,10,30,31,36,38–40,43–50,52 and sixteen studies measured skill examination scores.9,10,12,31,32,34–37,39,41,43,46,48,51,52 Fifteen studies investigated the students’ self-learning through questionnaires.27–29,31,33–36,38–41,43,45,47 One study42 was not included in the meta-analysis because its outcome indexes were investigated only by questionnaires. The sample sizes ranged from 36 to 320 participants, and the pooled sample size was 3694 (experimental group = 1896, control group = 1798). Fifteen studies were conducted in undergraduates, and 14 studies were conducted in associated degree students. Research settings included 25 schools...

![Flow diagram of included studies](image-url)
nation scores and student ID numbers. The allocation sequence by odd and even numbers based on the college entrance examination random numbers. Another two studies were separately generated according to the teacher-constructed examination or self-report.

3.4. The effectiveness of the flipped classroom in nursing education

The effects of the flipped classroom were measured by scores according to the teacher-constructed examination or self-report questionnaires. Major outcome indexes were (a) theoretical examination scores, (b) skills examination scores, (c) self-learning questionnaires, and (d) questionnaires used for teaching evaluation, student satisfaction, student attitudes, critical thinking and problem-solving skills.

3.4.1. The effectiveness of interventions on knowledge

We used the theoretical examination scores to check the students’ academic performance in knowledge. Sixteen studies tested the theoretical examination scores with pooled 2103 participants (experimental group = 1099, control group = 1004). Thirteen studies showed statistically significant differences between the flipped classroom and traditional lecture. There was high heterogeneity ($I^2 = 93\%$, $P < 0.00001$). Thus, a random-effects model was used. The pooled effect size showed a significant difference in theoretical examination scores ($SMD = 1.13$, 95% CI (0.76, 1.49), $P < 0.00001$) in favor of flipped classrooms compared with traditional lectures (Fig. 3). The results indicated that the flipped classroom improved students’ academic performance in knowledge. Due to the high heterogeneity among studies, we used subgroup analysis by education level. There was no significant difference in the subgroups ($P = 0.85$, $I^2 = 0\%$), which means that the heterogeneity was from intra-group differences rather than inter-group differences. A sensitivity analysis was carried out to verify the reliability of the results. This analysis was performed using sequential omission of individual studies one by one, and the pooled effect size that favored the flipped classroom group did not change the effects observed in the initial analysis. The funnel plot of the 16 studies with theoretical examination scores is shown in Fig. 4. The shape of the funnel plot is symmetrical indicating no significant publication bias.

### Table 1
Characteristics of included studies.

<table>
<thead>
<tr>
<th>Study (year)</th>
<th>Sample size (T/C)</th>
<th>Education degrees</th>
<th>Subject</th>
<th>Withdraw rate</th>
<th>Intervention</th>
<th>Outcome measures</th>
<th>T</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chen et al 2016</td>
<td>51/51</td>
<td>Associated degree students</td>
<td>Medical nursing</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>a, b</td>
<td></td>
</tr>
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<td>Physiology</td>
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<td>FC</td>
<td>LBC</td>
<td>a, d</td>
<td></td>
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<tr>
<td>Deng 2016</td>
<td>34/32</td>
<td>Undergraduate</td>
<td>Nursing instruction</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>a, c, f, g</td>
<td></td>
</tr>
<tr>
<td>Feng et al 2015</td>
<td>51/51</td>
<td>Associated degree students</td>
<td>Obstetric nursing</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>a, e</td>
<td></td>
</tr>
<tr>
<td>Gao 2016</td>
<td>72/68</td>
<td>Associated degree students</td>
<td>Nursing technology</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>a, b, c, f, h</td>
<td></td>
</tr>
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<td>Clinical area</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>a, b, e</td>
<td></td>
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<tr>
<td>Hu 2015</td>
<td>55/55</td>
<td>Associated degree students</td>
<td>Obstetric nursing</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>a, b, c</td>
<td></td>
</tr>
<tr>
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<td>Medical technology</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>b, d</td>
<td></td>
</tr>
<tr>
<td>Kou et al 2016</td>
<td>30/30</td>
<td>Undergraduate internship</td>
<td>Clinical area</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>a, b, c</td>
<td></td>
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<tr>
<td>Liu 2016</td>
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<td>Undergraduate</td>
<td>Nursing theory</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>a, d</td>
<td></td>
</tr>
<tr>
<td>Liu et al 2016</td>
<td>70/70</td>
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<td>Interventional therapy</td>
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<td>FC</td>
<td>LBC</td>
<td>a, c, e</td>
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<td>Nursing technology</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>a, b, c</td>
<td></td>
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<tr>
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<td>Associated degree students</td>
<td>Nursing foundation</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>b</td>
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<td>Medical nursing</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>e, g</td>
<td></td>
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<tr>
<td>Song et al 2016</td>
<td>30/30</td>
<td>Undergraduate</td>
<td>Nursing technology</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>b, e, e</td>
<td></td>
</tr>
<tr>
<td>Tao et al 2016</td>
<td>32/30</td>
<td>Undergraduate</td>
<td>Medical nursing &amp; nursing foundation</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>b, f</td>
<td></td>
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<tr>
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<td>193/129</td>
<td>Undergraduate</td>
<td>Nursing technology</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>a, b, c, d</td>
<td></td>
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<tr>
<td>Tian et al 2015</td>
<td>32/32</td>
<td>Undergraduate</td>
<td>Gerontology nursing</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>a, c</td>
<td></td>
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<tr>
<td>Xie 2015</td>
<td>50/50</td>
<td>Associated degree students</td>
<td>Pediatric nursing</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>a, g</td>
<td></td>
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<tr>
<td>Yan et al 2015</td>
<td>55/54</td>
<td>Associated degree students</td>
<td>Nursing technology</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>b, e</td>
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<tr>
<td>Yang 2016</td>
<td>64/64</td>
<td>Undergraduate</td>
<td>Preventive medicine</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>a, c, d</td>
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<tr>
<td>Ye et al 2016</td>
<td>43/42</td>
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<td>Clinical area</td>
<td>1</td>
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<td>LBC</td>
<td>c</td>
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<td>Undergraduate</td>
<td>Nursing technology</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>b, d</td>
<td></td>
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<td>Yin 2016</td>
<td>67/64</td>
<td>Associated degree students</td>
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<td>N/A</td>
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<td>LBC</td>
<td>a, c, f, h</td>
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<td>Zhang 2016</td>
<td>18/18</td>
<td>Undergraduate internship</td>
<td>Clinical area</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>b</td>
<td></td>
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<tr>
<td>Zhao et al 2016</td>
<td>115/114</td>
<td>Undergraduate</td>
<td>Nursing foundation</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>a, b, d</td>
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<tr>
<td>Zhao 2016</td>
<td>57/57</td>
<td>Associated degree students</td>
<td>Health assessment</td>
<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>a, c, e</td>
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<td>Zhong et al 2016</td>
<td>36/36</td>
<td>Undergraduate</td>
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<td>Zong et al 2016</td>
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<td>N/A</td>
<td>FC</td>
<td>LBC</td>
<td>b, c</td>
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</table>

Note: T: flipped classroom pedagogy; C: traditional lecture pedagogy; N/A: Non withdrawal; FC: flipped classroom; LBC: lecture-based classroom; a: theoretical scores; b: skill scores; c: self-learning questionnaire; d: teaching evaluation questionnaire; e: satisfaction questionnaire; f: study attitude questionnaire; g: critical thinking questionnaires; h: problem solving questionnaire.
Fig. 2. Risk of bias.

![Risk of bias chart](image1)

Fig. 3. Forest plot in theoretical examination scores.

![Forest plot](image2)

Fig. 4. Funnel plot in theoretical examination scores.

![Funnel plot](image3)
3.4.2. The effectiveness of interventions on skills

We used the skills scores to check the students’ academic performance in skills. Sixteen studies tested the skill examination scores with a pooled 2349 participants (experimental group = 1216, control group = 1133). Thirteen studies showed statistically significant differences between the flipped classroom and the control groups in skills scores. There was high heterogeneity ($I^2 = 95\%, P < 0.00001$). Thus, a random-effects model was used. The pooled effect size showed a significant difference in skills scores [SMD = 1.68, 95% CI (1.24, 2.12), $P < 0.00001$] in favor of a flipped classroom compared with traditional lectures. The results indicated that the flipped classroom improves students’ academic performance in skills with an effect size of 1.68. Subgroups by education level and research setting were analyzed (Fig. 5), and the performance in skills with an effect size of 1.68. Subgroups by education level and research setting were analyzed (Fig. 5), and the results showed that there was small inter-group heterogeneity ($I^2 = 11.9\%$). Thus, the majority of heterogeneity were still from intra-group variability. A sensitivity analysis was performed using sequential omission of individual studies. After excluding one study,[9] the heterogeneity was obviously diminished ($I^2 = 66\%$) in undergraduates, but the pooled effect size favored the flipped classroom [SMD = 1.65, 95% CI (1.41, 1.89), $P < 0.00001$] and did not change the effects observed in the initial analysis. The funnel plot for the 16 studies in the skill examination score analysis is shown in Fig. 6. This shape was mostly symmetrical indicating no significant publication bias.

3.4.3. The effectiveness of interventions on self-learning skill

Fifteen of the articles tested the self-learning skill of students with pooled 2119 participants (experimental group = 1099, control group = 1020). The effect size of 1.51 [95% CI (1.02, 2.01), $P < 0.00001$] means that students agree that flipped classroom has improved their self-learning skill. There is a relatively small heterogeneity existing according to the evaluation instruments through subgroup analysis, however, it is not the main heterogeneity sources (Fig. 7). The funnel plot for the 15 studies on the self-learning questionnaires analysis is shown in Fig. 8. The shape of the funnel plot is symmetrical indicating no significant publication bias.

3.4.4. The effectiveness of interventions assessed by questionnaires

Overall, nineteen articles investigated the students’ evaluations of the flipped classroom pedagogy through self-reported questionnaires in terms of teaching effectiveness,[10,12,18,20,39,41,46,49,50] student satisfaction,[9,27,29,34,42,45,48] student attitude,[10,12,27,47] critical thinking skills,[42,44,47] and problem-solving skills.[10,27] According to the questionnaire results, most students at the flipped classroom had positive comments about the flipped classroom. At least 90.4% of reported studies indicated an above average rating for students’ study enthusiasm in the flipped classroom approach, and 93.8% of students selected above average that flipped classrooms accelerate the communication between faculty and students. In all, 87% of the students reported that they preferred this approach and wanted to continue this approach in other subjects. There was also a statistically significant improvement in student satisfaction,[20,34,42] student study attitude,[27,47] and clinical thinking[8,42] in the flipped classroom compared with the traditional lecture.

4. Discussion

At first glance, evidence in favor of the flipped classroom seems strong because all studies indicated that flipped classroom students outperformed those in traditional lecture classrooms, especially in improving students’ academic performance both in knowledge and skills and self-learning ability. These results are in accordance with the findings of the previous narrative review related to foreign nursing education.[10,20] In the evaluation of teaching satisfaction and study attitude, these results also showed a relatively higher rating for the flipped classroom compared with the traditional lecture, which was contrary to some Western studies[5,13] that found improved examination scores and diminished student satisfaction. Several possible reasons may explain why Chinese students prefer flipped classrooms. First, usually, in traditional Chinese nursing education, students are not allowed to use cellphones and computers during the lecture. Second, the traditional lecture is quite repressed since most students are not allowed to discuss their opinions and always remain quiet. Third, students have few opportunities to communicate with the faculty after class, and the
flipped classroom may let students feel the faculty are more approachable. However, compared with the different culture in Western higher education, their traditional education has already adopted electronic equipment and encouraged them to share their opinions freely in the class, so they may not be curious about this pedagogy style, which may be why it received a low satisfaction rating due to the workload for class preparation.

Overall, in the pool of included studies, there was obvious heterogeneity, which may have resulted from the following factors. First, the different educational levels of the students resulted in the criteria for admission of nursing students being different. Second, the pooled studies focused on different nursing subjects. The third reason concerns the examination methods. Twenty-nine studies employed different appraisal tools. There were no unified criteria for the evaluation of the effectiveness of the flipped classroom. Fourth, each study employed a diverse range of preparatory and in-class active learning strategies as part of the flipped classroom intervention. These different teaching methods and objectives may have resulted in different effects, and this diversity may be the main cause of the heterogeneity among those studies.

Initially, the researcher was planning to synthesize the outcomes of questionnaires quantitatively. However, most of the studies used self-constructed questionnaires with a post-test and lacked comparison with traditional lectures. Meanwhile, the types of measurable data are different. Thus, the synthesis was not feasible. The researcher just described the aforementioned aspects related questionnaire surveys. However, most studies showed positive results for the flipped classroom.

5. Strengthens and limitations

In this review, we used a statistical method to validate the effectiveness of the flipped classroom in nursing education since all of the review papers before were narratives. It provided relatively
robust evidence to address the concerns of prior researchers. Meanwhile, this review was reproducible in terms of data extraction and synthesis. In addition, we registered in PRISMA with a protocol before we conducted this review, which decreased the bias in this review. In terms of limitations, no studies published in English met the inclusion criteria, and some of the Chinese studies were of poor quality. Fortunately, the sensitivity analyses showed that the outcomes of the study were reasonably stable.

As a result, the effectiveness of the flipped classroom was positive. However, two studies in the final pool that found no significant differences were excluded due to insufficient data. Therefore, we suppose that the extent of effectiveness may have diminished if we included them. On the other hand, in the measurable outcome indexes, knowledge can be objectively evaluated by theoretical examination, but the appraisal of skills and self-reported questionnaires are somehow subjective. Most studies did not report whether the implementation was blind or the surveys were anonymous, which is an important caveat when addressing survey results.

For future researchers, we recommend strengthening the instructional framework of flipped classroom pedagogy and formulating unified evaluation criteria. Additionally, there is a need for rigorous randomized controlled trial (RCT) designs for future studies to reduce the heterogeneity of the included articles. We also suggest that future reviewers perform meta-analyses to find sources of heterogeneity in this area.

6. Conclusions

This review indicated that the flipped classroom might help nursing students improve in knowledge, skills, self-learning, study satisfaction and enthusiasm. However, students’ critical thinking, problem-solving, and decision-making skills should be further validated by robust studies. Flipped classroom pedagogy is recommended, especially in Chinese nursing education reform. Since all of the included articles were in Chinese, the review highlights the lack of evidence about flipped classrooms in Western nursing education. Compared with the outcomes of Western studies of the effectiveness of the flipped classroom, Chinese studies showed more positive feedback.

Most importantly, to explore the rationale behind flipped classroom models, factors that will influence student performance also need to be included. Nursing educators could then translate these models in more strategic ways to transform the teaching-learning process.

Conflicts of interest

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