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Review

The effectiveness of a flipped classroom on the development of Chinese nursing students' skill competence: A systematic review and meta-analysis

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A R T I C L E I N F O

Keywords:
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A B S T R A C T

Objectives: Skill competence is essential for nursing students and flipped-classroom teaching has become increasingly popular in China's nursing education. However, no studies have yet specifically examined the effect of a flipped classroom versus a traditional classroom on their skill competence.
Design: A systematic review and meta-analysis of randomised controlled trials.
Data sources: The China National Knowledge Infrastructure, Wanfang Data, VIP, Superstar, PubMed, and Web of Science databases were searched from their inception until 9 June 2018.
Review methods: We screened the studies according to inclusion and exclusion criteria, extracted the data, and assessed the quality. Then, a meta-analysis was conducted.
Results: Twenty-two studies were eligible after reviewing 484 citations. The flipped classroom increased the students' skills score compared with the traditional teaching method (standardised mean difference = 1.79, 95% confidence interval: 1.32–2.27, p = 0.000). Additionally, it improved the cooperative spirit and sense of teamwork (effect size = 1.60, 95% confidence interval: 1.15–2.06), practical ability (effect size = 1.47, 95% confidence interval: 0.93–2.01), enjoyment of the course (effect size = 1.39, 95% confidence interval: 0.81–1.97), expression and communication (effect size = 1.41, 95% confidence interval: 0.69–2.12), the curriculum's effects (effect size = 1.32, 95% confidence interval: 1.00–1.64), interest in participation (effect size = 1.58, 95% confidence interval: 1.28–1.87), ability to think and analyse problems (effect size = 1.62, 95% confidence interval: 1.24–2.00), and resolution and resilience (effect size = 1.62, 95% confidence interval: 1.29–1.94).
Conclusions: The results suggest that the flipped classroom is more effective for the nursing students' skill competence than traditional teaching in China. However, due to heterogeneity and bias risk, a large sample and high-quality studies are needed in future to confirm its effectiveness.

1. Introduction

Clinical nursing skills are an essential component of nursing education and they are integral to the discipline of nursing (Asadizaker et al., 2015). Nowadays, the increasing complexity of the healthcare environment, extraordinary demands of patient health needs, and rapid advancement of healthcare technology means that nurses need to have a good grasp of clinical skills (Lee et al., 2010). In addition, the transition from being a nursing student to a professional nurse may be overwhelming and nursing students may be challenged by the need to assume the professional responsibility related to their licenced nurse roles. Furthermore, applying theoretical knowledge in real clinical settings and performing clinical skills are key challenges, which result in the nurses feeling stressed and incompetent (Chen et al., 2011). Therefore, nursing education requires nursing students to learn the clinical skills that are necessary to fulfil their role as nurses (Lee et al., 2011). However, traditional education is inadequate for meeting this requirement (Oyelana et al., 2018). As people are increasingly aware of the need for a paradigm shift, a brand-new teaching model, the flipped classroom, has arisen at this historic moment.

The 'flipped' or 'inverted' classroom is a special type of blended teaching (Sajid et al., 2016; Tugun et al., 2017), which was first described by Lage et al. in 2000 and later popularised by Bergmann and Sams in 2012 (Shiau et al., 2018). This model reverses the order of

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traditional in-class lectures being followed by homework elements (AlJarrah et al., 2018; Lin et al., 2017). In the flipped classroom, students voluntarily and actively study the lessons pre-class, and then resolve problems during the process of classroom discussion and cooperation (Jung et al., 2018). Unlike the passive teaching in traditional lectures, the flipped classroom involves student-centred participatory learning (Martinelli et al., 2018; Menegaz et al., 2018; Park et al., 2018).

It is generally accepted that the flipped classroom can produce positive results. Previous research has shown that the flipped classroom can improve academic performance (Lee et al., 2017), self-directed learning ability, critical thinking disposition (Kim and Kim, 2017; Simpson and Richards, 2015), and student satisfaction (Kim and Jang, 2017). However, some studies have revealed that the students' satisfaction with flipped-classroom teaching is relatively low (Missildine et al., 2013). In addition, the effects of the flipped classroom in terms of changing the students' skills are uncertain (Chen et al., 2017). Abeysekera and Dawson (2015) argue that this teaching arrangement has not been sufficiently studied and that there is a lack of empirical evidence for its effectiveness (Abeysekera and Dawson, 2015). Therefore, it is necessary to provide more conclusive evidence to prove its impact on skill change.

As the most populous country in the world, China has a large and complex health professional education system (Hou et al., 2014). In recent years, due to the reform of the health system in China, the medical education method has also undergone substantial changes. Previous studies have found that the theoretical knowledge of Chinese nursing students, cultivated by traditional teaching methods, is relatively solid and yet their ability to actually perform these skills is poor (Li et al., 2018). As a passive recipient of knowledge, nursing students are prone to learn by rote, and superficial rote memorisation eventually leads to a growing gap between nursing theory and practice (Bressington et al., 2018). As an emerging pedagogical approach, the flipped classroom teaching method has been rapidly developing in nursing education. It has changed traditional Chinese education that follows the teacher-oriented model, which places great emphasis on disseminating factual knowledge that the students passively receive. In consideration of the great demand for high-level nursing in China, the implementation and application of flipped classroom teaching may be particularly meaningful when revising the curriculum.

A recent study showed that, compared with the traditional classroom, the flipped-classroom teaching method is more effective for improving students' theoretical knowledge and skills score (Hu et al., 2018). However, this meta-analysis was restricted to Chinese baccalaureate nursing students and the sample size in the study was relatively small. Regarding the outcome of the students' skills score, only five studies were included in the meta-analysis. In addition, the study lacked evaluation of student feedback, such as student satisfaction, student motivation, and teamwork.

The uncertainty about the validity of the flipped classroom and the heterogeneity in the published literature has provided the impetus for the current research. The objective of the present systematic review and meta-analysis was to further evaluate the effectiveness of the flipped classroom on nursing students' skill competence and other factors, compared with the traditional classroom, and to conduct a quantitative evaluation using a meta-analysis. The quantitative evaluation could provide new insights on the implementation of the flipped classroom, which will provide the basis for an intervention in Chinese nursing education. Furthermore, this meta-analysis will publicise the significance of the flipped classroom in Chinese nursing education to international education researchers.

2. Methods

2.1. Search strategies

A systematic search of the China National Knowledge Infrastructure, Wanfang Data (a Chinese database), VIP (a Chinese database), and Superstar (a Chinese database), and of English-language computerised databases, such as PubMed and Web of Science, was performed from the inception of the databases until 9 June 2018. Articles published in English or Chinese were considered.

The Medical Subject Headings terms or keywords ('flip* class*' OR 'flip* learn*') AND ('invert* class*' OR 'invert* learn') AND ('nurs*' OR 'nurs* student*' OR 'nurs* educ*') AND ('skill*' OR 'technique*' OR 'practice*') AND ('intervention' OR 'controlled') AND ('China' OR 'Chinese') were used to obtain the search string. In addition, the references of the retrieved studies were manually searched to locate any additional studies.

2.2. Study selection

We independently scrutinised the electronic searches and obtained the full articles of all citations that were potentially eligible for inclusion. The eligibility criteria for inclusion in the systematic review included that the article (1) described a randomised controlled trial; (2) used Chinese secondary vocational students, junior college students, and nursing undergraduates; (3) used the flipped classroom as an educational approach in the intervention group; (4) used traditional teaching in the control group; (5) evaluated clinical nursing skills as an outcome; and (6) reported the sample size, the mean difference, and associated 95% confidence interval (CI) of the nursing skills scores for the intervention group and control group. The exclusion criteria were that (1) the study was a non-randomised controlled trial; (2) it included a higher grade, from junior college student to university student, doctoral student, or postgraduate student; (3) it did not evaluate the nursing skills scores; (4) it had incomplete data, such as lacking sufficient information to calculate effect size (ES) (e.g. sample sizes), or the effort to obtain data from the corresponding authors was unsuccessful; (5) we failed to obtain the full text; (6) it used non-focused teaching; and (7) it was a duplicate article.

The final list of included studies was decided during our discussion and full agreement was required prior to inclusion. Any discrepancies were solved after a discussion.

2.3. Data extraction

The relevant information from the included studies was independently extracted by us. Discrepancies were settled by discussion to achieve a consensus. The data extraction was performed by completing a table with the following data: authors, publication year, sample size (the experimental group and control group), educational background, the nursing course involved, the timing of course preparation, the timing of the intervention, and the investigation index.

2.4. Quality assessment

We independently appraised the potential risk of bias in the randomised controlled trials using the Cochrane Risk Assessment Tool. The following items were evaluated: random sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias), and other possible causes of bias. For all randomised controlled trials, each item was described as having a low risk of bias, a high risk of bias, or an unclear risk of bias.

2.5. Statistical analyses

All analyses were performed using Review Manager 5.3 (The Cochrane Collaboration, Copenhagen, Denmark) and STATA 12.0 (StataCorp., College Station, TX, USA). The dichotomous data were analysed using the ES values and the 95% CI for the ES. For the continuous data, Cohen's *d* values and the 95% CI were used as the ES statistic. Statistical heterogeneity among the studies was tested using the $\chi 2$ test and I^2 statistic. If $p > 0.1$ and $I^2 < 50\%$, which suggests that there is homogeneity between the results of the studies, a fixed-effects model was used for the meta-analysis. If $p < 0.1$ and $I^2 > 50\%$, which is considered to indicate that there is significant heterogeneity, it was necessary to analyse the source of the heterogeneity. If there was significant heterogeneity, a random-effects model was used. The ES were combined using the inverse variance method.

If there was heterogeneity between the studies, subgroup analyses were performed based on the reasons that may lead to heterogeneity. Sensitivity analysis was utilised to judge the stability of the results. We assessed publication bias using Egger's test and Begg's test.

3. Results

3.1. Literature searches

The literature search yielded a total of 733 potentially relevant studies. Of these initial records, 249 studies were excluded due to duplication. After reviewing the titles and abstracts, 82 articles were retained for further examination. Sixty articles were excluded because they did not meet the inclusion criteria. Finally, a total of 22 studies (Ai et al., 2017; Chen et al., 2018; Deng et al., 2017; Fu et al., 2017; Guo et al., 2017a; Guo et al., 2017b; Ji et al., 2016; Li, 2016; Li, 2017a; Li, 2017b; Liu et al., 2016; Qiu and Zhan, 2017; Sun et al., 2017; Tian, 2016; Wang et al., 2017; Wen et al., 2018; Wu, 2016; Yan and Xie, 2015; Yang and Liu, 2017; Zhang et al., 2017; Zheng et al., 2017; Zong et al., 2016) were included in this meta-analysis. The inclusion process of all studies is presented in Fig. 1.

3.2. Study characteristics

A summary of the study characteristics is shown in Table 1. In total, 22 randomised controlled trials were included, and 4295 students were included in the 22 studies. Among them, there were 2188 students in the experimental group and 2107 students in the control group. The 22 included randomised controlled trials were all published between 2015 and 2018 in Chinese journals. All were written in Chinese and were performed in China, which shows a recent growing interest in the flipped classroom by Chinese people. The study populations were diverse as they included secondary vocational students and junior college students as well as undergraduate level learners. The sample size varied from 82 to 538 participants. The included studies involved different nursing courses, such as the Fundamentals of Nursing, Obstetrics and Gynaecological Nursing, Surgical Nursing, and Paediatric Nursing. The duration of the study interventions also varied in length from being less than one semester to one semester or longer. All the study outcomes were measured using the skills score. All studies mentioned the general conditions of gender, age, school performance, and so on in the intervention group and control group, which indicates that all of the pre-intervention baseline levels were consistent and comparable.

3.3. Risk of bias in the included studies

The risk of bias in the included studies is shown in Fig. 2. Table 2 also shows the risk of bias assessment of the 22 included studies. All studies reported randomisation, but only 12 studies reported their randomised sequence generation methods. Of these 12 studies, eight used cluster random sampling, two used a lottery, one used the touch ball method, and one study utilised the random equilibrium sequential method. We believe that these 12 studies had a lower bias risk for generating random sequences. None of the studies described their allocation concealment. Only one study reported that the assessors were blinded. All studies reported complete outcome data. We considered the 22 studies to be free of selective reporting and other biases. Moreover, all the studies reported that there were no statistically significant differences in age, sex, or academic achievement between the flipped teaching and traditional teaching groups at the baseline.

3.4. Meta-analysis results

All studies utilised the students' skills score as an outcome measure. In the random-effects model, we found that the flipped classroom significantly improved the operational performance of the nursing students compared with the traditional classroom (standardised mean difference = 1.79, 95% CI: 1.32–2.27, $p = 0.000$) (Fig. 3). We found that the research studies had a high level of heterogeneity ($I^2 = 97.8\%$).

The results of the secondary outcome indicators are shown in Table 3. After merging the nursing students' feedback about the flipped classroom, it was found that 10 studies reported the nursing students' cooperative spirit and sense of teamwork, six studies reported the practical ability, six studies reported the degree of enjoyment of the courses, eight studies reported expression and communication, eight studies reported the effects of the course, fifteen studies reported participation interest, five studies reported the ability to think and analyse problems, and five studies reported the nursing students' resolution and resilience. The results showed that the experimental group improved in the cooperative spirit and sense of teamwork (ES = 1.60, 95% CI: 1.15–2.06), practical ability (ES = 1.47, 95% CI: 0.93–2.01), degree of enjoyment of the course (ES = 1.39, 95% CI: 0.81–1.97), expression and communication (ES = 1.41, 95% CI: 0.69–2.12), effects of the curriculum (ES = 1.32, 95% CI: 1.00–1.64), interest in participation (ES = 1.58, 95% CI: 1.28–1.87), ability to think and analyse problems (ES = 1.62, 95% CI: 1.24–2.00), and resolution and resilience (ES = 1.62, 95% CI: 1.29–1.94).

In order to find the source of the heterogeneity, subgroup analyses were performed according to the strata of gender, educational background, duration of intervention, subject, and area. The classification of the type of urban area used the classification criteria of Huang et al. (Huang and Chen, 2015). According to the size of the city and the degree of clustering, the intervention sites were divided into I, II, III, and other urban agglomerations.

The results of the subgroup analyses are presented in Table 4. After the subgroup analyses, we found that the skills score of the experimental group was higher than that of the control group (Fig. 4). In addition, the heterogeneity tests showed that there was still significant heterogeneity among the different subgroups ($I^2 > 50\%$), which explains that the abovementioned factors are not related to the heterogeneity. Although the subgroup analyses were conducted, it was still not possible to explain the unknown heterogeneity, which weakens the reliability of the meta-analysis estimates.

Begg's test and Egger's test were used to analyse the publication bias. If $p < 0.05$, there might be a publication bias. The results indicated that a publication bias may exist in the abovementioned research results.

We also conducted a sensitivity analysis. In order to evaluate the statistical stability of the results, a single study was removed from the meta-analyses each time to show the effect of a single dataset on the merged results. The sensitivity analysis is shown in Fig. 5. It was found that when four studies (Chen et al., 2018; Guo et al., 2017a; Tian, 2016; Wu, 2016) were excluded, the overall results had a great impact. We read and analysed these four articles carefully and found that the influence of Chen et al. (2018)'s research on the results may arguably have been related to the sample size as the sample size of the study was much larger than the other studies considered. In addition, the

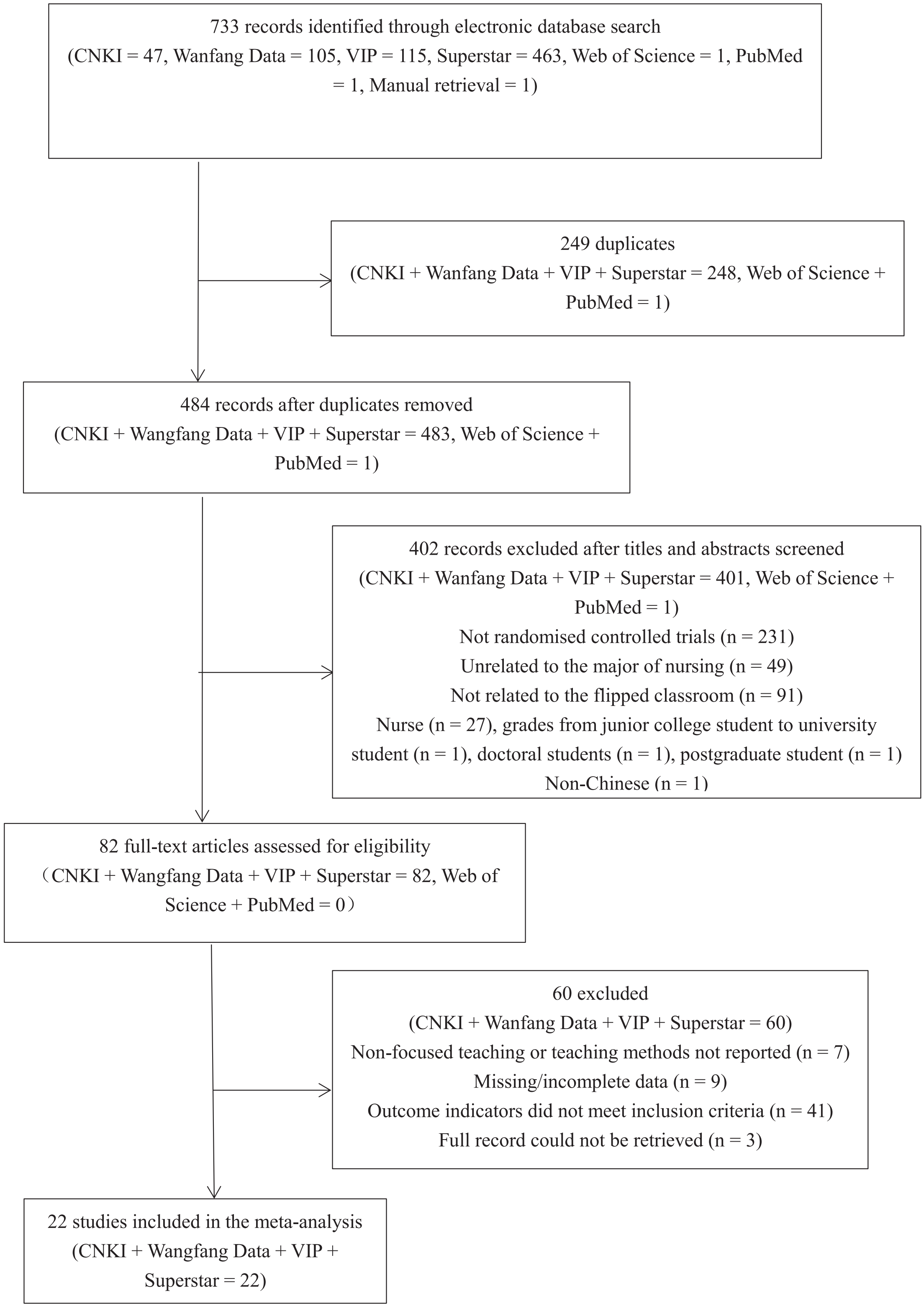

Fig. 1. Flow chart of the literature search. CNKI, China National Knowledge Infrastructure.

differences in Wu's (2016) research are related to the study of secondary professional students, as most of the research subjects in 22 studies are junior college students and undergraduates. Tian (2016) assessment of the skill scores focused on the context of the clinical skill operation which was different from the other studies that typically emphasized the clinical skill operation itself. Guo et al. (2017a) research adopted the mixed learning method of combining massive open online courses with the flipped classroom. In comparison to utilizing only the flipped classroom, the mixed learning method affected the results to a certain extent. After excluding these four studies, the results showed that the size of the combined effect was beneficial to the flipped classroom group (standardised mean difference = 1.84, 95% CI: 1.43–2.25, p = 0.000). Compared to our main results, the differences in the skill scores did not change materially but efficiency improved.

Table 1
Characteristics of the 22 studies of the effect of the flipped classroom on nursing students' education in China.

Study ID	Study design	IG (*N*)	CG (*N*)	Educational background	Subjects	The timing of course preparation	Duration of intervention	Outcomes
Chen XQ 2018	RCT	FC (284)	LBC (254)	Junior college	Emergency nursing	Two weeks before class	32 class hours	① ⑤ ⑨ ⑪
Wen CL 2018	RCT	FC (84)	LBC (78)	Junior college	Internal medicine nursing	One week before class	NA	① ② ④ ⑦
Ai YS 2017	RCT	FC (48)	LBC (50)	Junior college	Emergency nursing	NA	Four class hours	① ② ④ ⑧ ⑩
Deng XB 2017	RCT	FC (51)	LBC (50)	Junior college	Surgical nursing	One week before class	One semester	① ② ③ ④ ⑥ ⑦ ⑧ ⑨ ⑩
Fu XH 2017	RCT	FC + PBL (49)	LBC (49)	Junior college	Surgical nursing	Two weeks before class	Four class hours	① ② ⑧
Guo J 2017	RCT	FC + MOOCs (90)	LBC (90)	Junior college	Comprehensive skills training	NA	One semester	① ④ ⑧ ⑨
Guo YJ 2017	RCT	FC (56)	LBC (58)	Junior college	Obstetrics and gynaecological nursing	NA	NA	① ② ④ ⑥ ⑦ ⑩
Li J 2017	RCT	FC (41)	LBC (41)	Undergraduate	Surgical nursing	NA	NA	① ⑪
Li L 2017	RCT	FC (100)	LBC (100)	Junior college	Community nursing	One week before class	One semester	① ④ ⑤ ⑧ ⑩
Qiu ML 2017	RCT	FC (57)	LBC (58)	Secondary vocational school education	Surgical nursing	One week before class	NA	① ④ ⑤ ⑦ ⑥ ⑧ ⑩
Sun Y 2017	RCT	FC + PBL + CBL (208)	LBC (217)	Junior college	Obstetrics and gynaecological nursing	Two weeks before class	Eight class hours	① ② ⑤ ⑦⑧ ⑨
Wang B 2017	RCT	FC (64)	LBC (57)	Junior college	Surgical nursing	NA	Half of the semester	① ⑤ ⑪
Yang N 2017	RCT	FC (60)	LBC (60)	Junior college	Paediatric nursing	NA	NA	① ⑪
Zhang HM 2017	RCT	FC (49)	LBC (46)	Undergraduate	Fundamentals of nursing	One week before class	28 class hours	① ② ④ ⑧
Zheng CH 2017	RCT	FC (100)	LBC (118)	Junior college	Obstetrics and gynaecological nursing	NA	10 class hours	① ② ③ ④ ⑤ ⑧ ⑨
Ji HX 2016	RCT	FC (120)	LBC (122)	Junior college	Surgical nursing	NA	20 class hours	① ② ④ ⑧
Li CY 2016	RCT	FC (90)	LBC (92)	Undergraduate	Fundamentals of nursing	NA	Three months	① ② ④ ⑧
Liu P 2016	RCT	FC (153)	LBC (146)	Junior college	Comprehensive skills training	One week before class	One semester	① ⑧
Tian ZJ 2016	RCT	FC (193)	LBC (127)	Undergraduate	Fundamentals of nursing	NA	90 class hours	① ④
Wu Y 2016	RCT	FC (135)	LBC (140)	Secondary vocational school education	Fundamentals of nursing	NA	One semester	① ③ ⑦ ⑧
Zong MZ 2016	RCT	FC (101)	LBC (100)	Junior college	Fundamentals of nursing	NA	Eight months	① ⑧
Yan LX 2015	RCT	FC (55)	LBC (54)	Junior college	Comprehensive skills training	One week before class	32 class hours	① ④ ⑥ ⑨ ⑩

Note: ① skill score; ② team consciousness and cooperation ability; ③ improvement of practical ability; ④ enhancement of participation interest; ⑤ overall effect; ⑥ thinking and analytical ability; ⑦ expression and communication ability; ⑧ improvement of self-learning ability; ⑨ love the course; ⑩ problem-solving ability; ⑪ satisfied with the course.
ID, identification; IG, intervention group; CG, control group; RCT, randomised controlled trial; NA, not available; LBC, traditional classroom; FC, flipped classroom; PBL, problem-based learning; CBL, case-based learning; MOOCs, Massive open online courses.

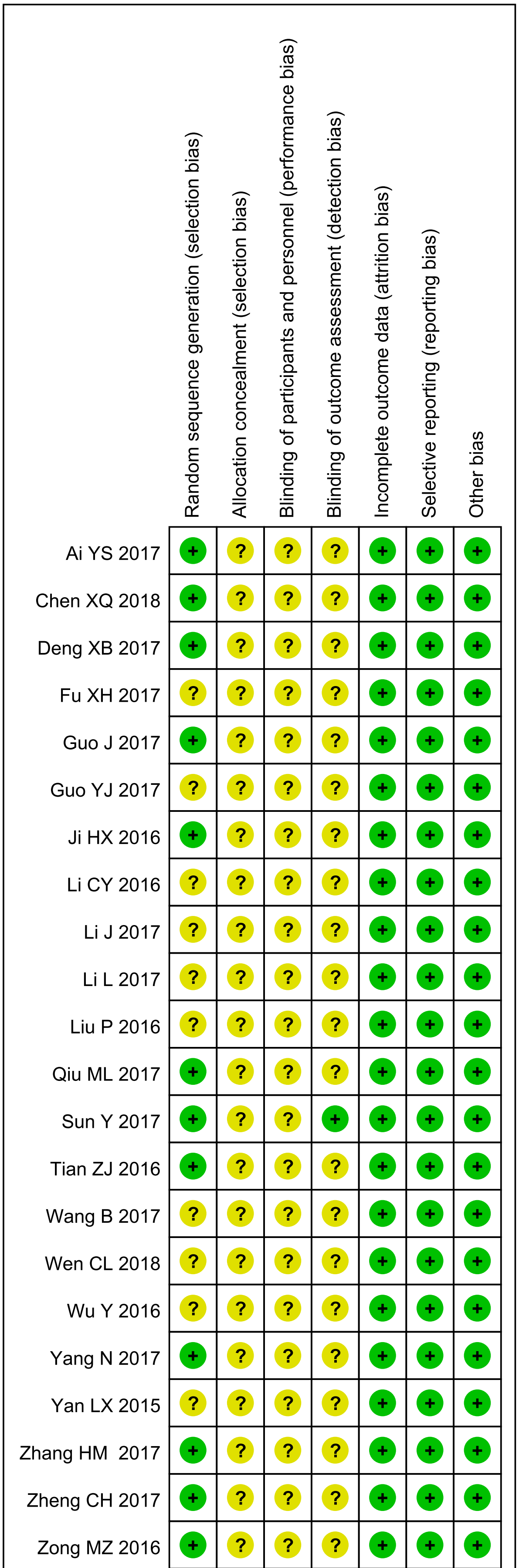

Fig. 2. Risk of bias summary.

4. Discussion

4.1. Summary of the main findings

Previous meta-analyses of studies that had a small sample and a lack of student feedback did not have sufficient data to test the effects of the flipped classroom on the ability of Chinese nursing students and other aspects of development. The current meta-analysis of the 22 studies is the first systematic report to summarise the effect of the flipped classroom on the skills score and other aspects of Chinese nursing students. This study indicated that the flipped classroom significantly improved Chinese nursing students' skill competence. In addition, compared with the traditional classroom, the flipped classroom is more effective for improving the spirit of cooperation, practical ability, degree of enjoyment of the course, expression and communication, effects of the curriculum, interest in participation, ability to think and analyse problems, and resolution and resilience.

There are some explanations for why flipped-classroom learning is better than the traditional classroom. First, the flipped-classroom model is student-centred and it makes students responsible for their own learning (Shiau et al., 2018). By using mobile learning applications, students can spend more time on extracurricular learning in order to gain more knowledge, which is not available in the traditional teaching method (Zheng et al., 2018). Additionally, the flipped classroom contributes to enhancing the students' learning initiative and learning effect (Bechter and Swierczek, 2017; Lin et al., 2017). Second, the flipped classroom takes into account the individual differences of the students (Elian and Hamaidi, 2018). Online lectures enable students to be more flexible in their learning and they can learn at their own speed and conduct problem-based activities in the classroom, which is conducive to their in-depth understanding of the problem (Ponikwer and Patel, 2018). Third, the flipped classroom can become a clinical learning environment that deepens the nursing students' understanding of the professional roles (Saunders et al., 2017), and it is an interactive learning environment in which educators can guide students in applying concepts and participating creatively (Presti, 2016). The flipped classrooms can also increase the students' pleasure in learning (Chen et al., 2017). Furthermore, the flipped classroom can help nursing students to accurately grasp diverse and complicated scenarios and to respond creatively in order to foster superb decision-making and problem-solving skills (Lee and Hwang, 2016). Fourth, through the application of the flipped-classroom teaching, students can more effectively and independently interact with learning materials; thus, it increases the cooperation with their classmates in the classroom, and increases the interaction between students and teachers (Limniou et al., 2018).

4.2. Strengths and limitations

This systematic review and meta-analysis have several advantages, as follows. In recent years, with the development and reform of nursing education, the Chinese universities have adopted the flipped classroom as a new teaching model, and the number of papers on the application of the flipped classroom in Chinese universities has increased significantly. However, the flipped classroom is influenced by the school's resources and equipment, the design and content of the curriculum, the number of students, the quality of the students, and so on. Therefore, it was necessary to conduct a scientific assessment of the flipped-classroom teaching model, which helps to further promote the extension of the teaching model. In this meta-analysis, we examined more randomised controlled trials and included a variety of educational levels of the nursing students to examine the effects of the flipped classroom on the development of Chinese nursing students' skill competence. Our research did not include higher grades from junior college student to university student, postgraduate students, and doctoral students, because the way of teaching is distinct from the teaching of other students in China. In addition, we analysed the students' feedback about the

Table 2
Risk of bias assessment of the 22 included studies.

Study ID	Random sequence generation	Allocation concealment	Blinding of participants	Blinding of operator	Blinding of outcome assessment	Incomplete outcome data (report)	Selective reporting (report)	Other bias
Chen XQ 2018	Yes (touch ball method)	Unclear	Unclear	Unclear	Unclear	None	None	None
Wen CL 2018	Unclear	Unclear	Unclear	Unclear	Unclear	None	None	None
Ai YS 2017	Yes (cluster random sampling)	Unclear	Unclear	Unclear	Unclear	None	None	None
Deng XB 2017	Yes (cluster random sampling)	Unclear	Unclear	Unclear	Unclear	None	None	None
Fu XH 2017	Unclear	Unclear	Unclear	Unclear	Unclear	None	None	None
Guo J 2017	Yes (cluster random sampling)	Unclear	Unclear	Unclear	Unclear	None	None	None
Guo YJ 2017	Unclear	Unclear	Unclear	Unclear	Unclear	None	None	None
Li J 2017	Unclear	Unclear	Unclear	Unclear	Unclear	None	None	None
Li L 2017	Unclear	Unclear	Unclear	Unclear	Unclear	None	None	None
Qiu ML 2017	Yes (lottery)	Unclear	Unclear	Unclear	Unclear	None	None	None
Sun Y 2017	Yes (cluster random sampling)	Unclear	Unclear	Unclear	Yes	None	None	None
Wang B 2017	Unclear	Unclear	Unclear	Unclear	Unclear	None	None	None
Yang N 2017	Yes (stochastic balanced sequential method)	Unclear	Unclear	Unclear	Unclear	None	None	None
Zhang HM 2017	Yes (cluster random sampling)	Unclear	Unclear	Unclear	Unclear	None	None	None
Zheng CH 2017	Yes (lottery)	Unclear	Unclear	Unclear	Unclear	None	None	None
Ji HX 2016	Yes (cluster random sampling)	Unclear	Unclear	Unclear	Unclear	None	None	None
Li CY 2016	Unclear	Unclear	Unclear	Unclear	Unclear	None	None	None
Liu P 2016	Unclear	Unclear	Unclear	Unclear	Unclear	None	None	None
Tian ZJ 2016	Yes (cluster random sampling)	Unclear	Unclear	Unclear	Unclear	None	None	None
Wu Y 2016	Unclear	Unclear	Unclear	Unclear	Unclear	None	None	None
Zong MZ 2016	Yes (cluster random sampling)	Unclear	Unclear	Unclear	Unclear	None	None	None
Yan LX 2015	Unclear	Unclear	Unclear	Unclear	Unclear	None	None	None

Note: ID, identification.

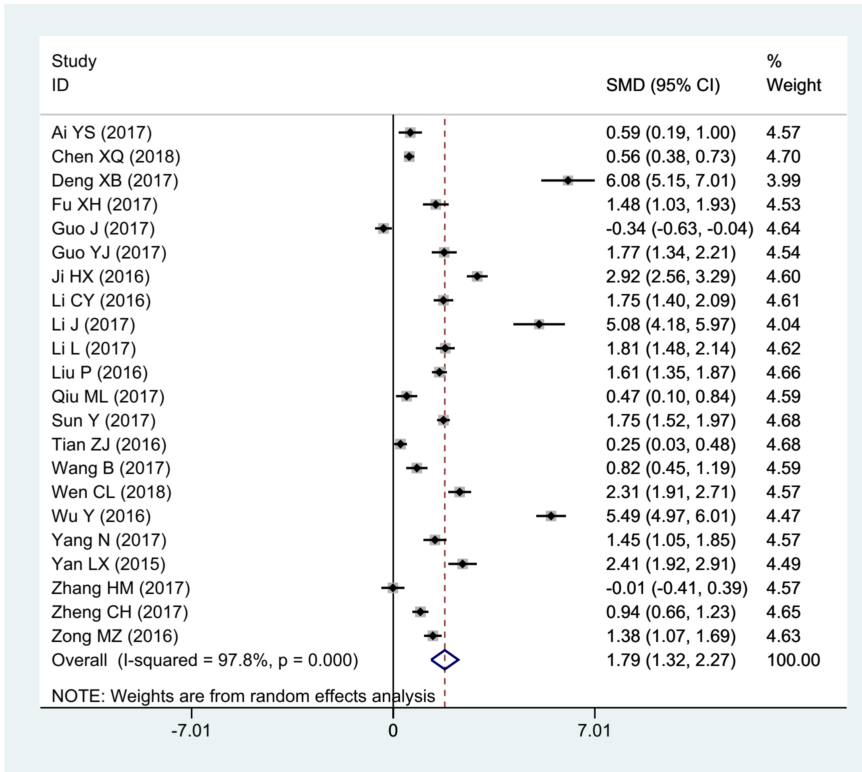

Fig. 3.. Forest plot of the nursing students' skills score.

Table 3
The result of the secondary outcome indicator.

Students' feedback	Number of included studies	Effect size (95% confidence interval)	I^2	*p* (Egger's test)	*p* (Begg's test)
Cooperative spirit and sense of teamwork	10	1.60 (1.15, 2.06)	75.9%	0.01	0.00
Practical ability	6	1.47 (0.93, 2.01)	79.0%	0.30	1.000
The degree of love for the course	6	1.39 (0.81, 1.97)	65.7%	0.37	0.45
Expression and communication	8	1.41 (0.69, 2.12)	91%	0.01	0.27
Effects of the curriculum	8	1.32 (1.00, 1.64)	61.2%	0.96	0.92
Participation interest	15	1.58 (1.28, 1.87)	65.0%	0.44	0.16
Ability to think and analyse problems	5	1.62 (1.24, 2.00)	35.4%	0.75	0.09
resolution and resilience	5	1.62 (1.29, 1.94)	20.7%	0.54	1.000

flipped classroom, which enabled us to gain a more comprehensive understanding of the impact of the flipped teaching on the nursing students.

This meta-analysis also has several limitations. First, there was significant heterogeneity in both the overall and subgroup analyses, which weakens the reliability of the meta-analysis estimates. This may have been caused by the following factors: (1) the difference in the evaluation methods of the skills score may be the main reason for the considerable heterogeneity among the results, which affects the reliability of the results to a certain extent; (2) different schools have different teaching methods, teaching content, and teaching objectives for nursing students, such as differences in the platform for the flipped-classroom implementation, teacher experience, and learning materials before class; and (3) the quality of the included studies is low, which may lead to the extreme heterogeneity in the study. Second, some limitations are associated with the publication bias, which may have occurred because positive results are more easily published. In addition, flaws in the study design may have exaggerated the advantages of the flipped classroom. Third, there were defects in the inclusion of the research methodology, such as the failure to elaborate the generation of random sequences, and the allocation of hidden and blind methods was unclear. Finally, the outcome indicators for each included study were not the same, which may have affected the strength of the argument to some extent.

4.3. Implications for future research

The implementation of the flipped classroom is basically in its initial stages in China, and this model should be promoted in future nursing education. In order to understand the flipped classroom more objectively and fully, it is necessary to promote further application of the flipped classroom in China. Future research also needs to take into account other factors that influence the effect of overturning the classroom, such as the time involved in pre-class assignments, the type and length of the videos, the workload of the students, and the role of the teacher in the flipped classroom.

5. Conclusion

The flipped classroom seems to improve the skill competence of Chinese nursing students when compared with the traditional teaching. However, the high heterogeneity, lower methodological quality, and the publication bias of the included studies cannot be neglected. Future research needs to adopt strict inclusion criteria and rigorous methods of

Table 4
Subgroup analyses of the nursing skills scores' outcomes stratified by the various contexts.

Characteristics	n	Pooled Cohen's d (95% confidence interval)	p	Heterogeneity test		p (Begg's test)	p (Egger's test)
				I^2	p		
Gender					0.00		
Female	3	2.39 (0.16, 4.61)	0.00	99.1%		0.60	0.54
Mixed	10	1.30 (0.78, 1.82)	0.00	96.4%		0.33	0.18
No report	9	2.15 (1.34, 2.96)	0.00	97.6%		0.06	0.04
Educational background					0.00		
Undergraduate	4	1.69 (0.34, 3.04)	0.00	98.0%		0.17	0.24
Junior college	16	1.67 (1.21, 2.12)	0.00	96.8%		0.15	0.02
Secondary vocational school education	2	2.98 (−1.95, 7.90)	0.00	99.6%		0.32	–
Duration of intervention					0.00		
Short-term	4	1.20 (0.66, 1.74)	0.00	91.1%		0.50	0.44
Medium-term	6	1.40 (0.54, 2.26)	0.00	97.6%		0.57	0.27
Long-term	7	2.28 (1.08, 3.47)	0.00	98.9%		0.05	0.03
No report	5	2.15 (1.11, 3.19)	0.00	96.3%		0.14	0.09
Subject					0.00		
Surgical nursing	6	2.75 (1.40, 4.10)	0.00	98.0%		0.09	0.09
Fundamentals of nursing	5	1.76 (0.31, 3.21)	0.00	98.9%		0.14	0.16
Comprehensive skills training	3	1.22 (−0.33, 2.77)	0.00	98.5%		0.60	0.77
Obstetrics and gynaecological nursing	3	1.48 (0.92, 2.05)	0.00	90.6%		0.60	0.96
Emergency nursing	2	0.56 (0.40, 0.72)	0.87	0.0%		0.32	–
Other	3	1.86 (1.40, 2.32)	0.01	77.7%		0.60	0.96
Area					0.00		
Type I	6	0.70 (0.13, 1.28)	0.00	95.9%		0.85	0.93
Type II	2	1.76 (−0.52, 4.04)	0.00	98.6%		0.32	–
Type III	5	2.36 (1.06, 3.65)	0.00	97.6%		0.05	0.05
Other	9	2.26 (1.44, 3.07)	0.00	98.1%		0.21	0.03

Note: Mixed: male and female.

quality assessment. In addition, this finding needs to be confirmed in a larger sample and with high-quality studies.

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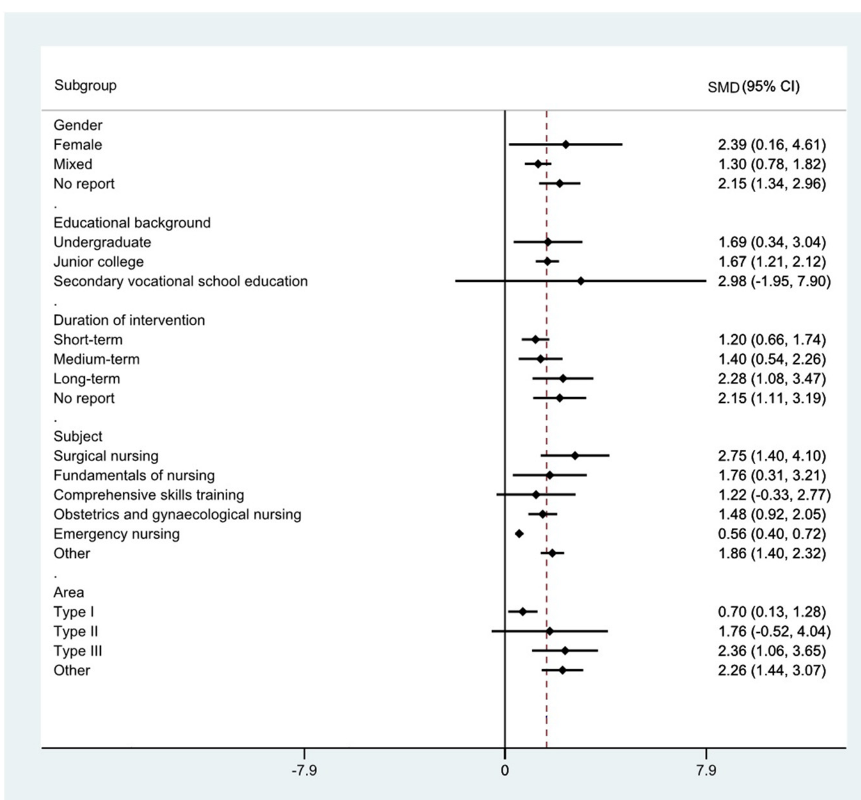

Fig. 4.. Summary of subgroup analyses for the skills score.

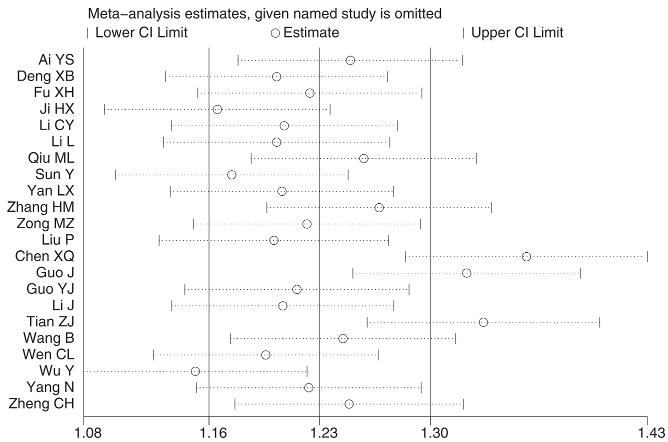

Fig. 5.. Sensitivity analysis.

Declaration of Competing Interest

None.

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