The effects of blended learning on knowledge, skills, and satisfaction in nursing students: A meta-analysis

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ARTICLE INFO	ABSTRACT
	Objective: The aim of this meta-analysis is to investigate the effects of blended learning on nursing students' knowledge, skills and satisfaction. *Methods:* We searched EMBASE, PubMed, CINAHL, Cochrane Library for publications in English up to December 2018. Two researchers independently screened the literature and extracted the data. Meta-analysis was performed with Revman5.0 for the eligible studies. *Results:* A total of 8 studies met the inclusion criteria of meta-analysis, including 574 nursing students. Compared with traditional teaching, blended learning could effectively improve nursing students' knowledge (SMD = 0.70, 95% CI [0.52, 0.87], $P < 0.00001$) and satisfaction (SMD = 0.72, 95% CI [0.08, 0.59], $P = 0.01$), and tended to improve the skills although without significant difference (SMD = 0.58, 95% CI [−0.17, 1.32], $P = 0.13$). *Conclusions:* Blended learning can effectively improve the knowledge and satisfaction of nursing students. Therefore, blended learning can be used as a teaching method in nursing education.

1. Introduction

In the past 30 years, internet and information technology have been widely used in higher education (De Gagne et al., 2018). Due to the shortage of nursing teachers, the limited class schedule of students and the lack of clinical experience (Hansen et al., 2011; Lee et al., 2016), there is criticism that undergraduate education does not provide nursing students with sufficient opportunities to prepare for future career (McDonald et al., 2018). It is difficult for nursing students to acquire enough knowledge only through face-to-face traditional teaching.

Online learning increases the way of acquiring knowledge by nursing students and solves the problem of shortage of teaching staff to some extent (Cook et al., 2008; McCartney and Morin, 2005). Through rich teaching resources, students have deepened their understanding and memory of knowledge concepts. Most importantly, self-paced learning enables students to use their previous learning experience in their current learning (Gerdprasert et al., 2010). At present, more teachers are integrating online tools into regular teaching methods to form new teaching models. However, some students complain that online learning sometimes fails to provide timely feedback and response compared with traditional learning. In addition, the use of online learning may affect academic performance due to the lack of

supervision (Nkenke et al., 2012). Therefore, it has been pointed out that blended learning is a better alternative to education (Kang and Seomun, 2018).

The blended learning is a new education method that combines face-to-face traditional learning with online learning (Kang and Seomun, 2018). Blended learning not only has the convenience, autonomy and richness of online learning, but also strengthens the connection between teachers and students, so that students can get effective feedback in time. Many qualitative studies have shown that blended learning can improve students satisfaction (Adams and Timmins, 2006; Ireland et al., 2009; So, 2009). Some studies have shown that blended learning improves the professional knowledge of nursing students (Sherman et al., 2012). However, blended learning was reported to improve the performance skills but not improve knowledge (Kaveevivitchai et al., 2009).

Although blended learning has many advantages, few studies have investigated blended learning in the field of nursing education. A systematic review reported that it is possible to improve students' clinical competences through blended learning (Rowe et al., 2012). However, this systematic review included studies of health students rather than nursing students. A meta-analysis evaluated the effectiveness of online or blended learning vs. face-to-face learning in undergraduate nurse

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education, but this study confused blended learning with online learning and did not separate blended learning from pure online learning (McCutcheon et al., 2015).

To the best of our knowledge, there is still no systematic review of blended learning for nursing students. Therefore, we conducted this meta-analysis to investigate the impact of blended learning on knowledge, skills and satisfaction in nursing students compared to traditional education methods.

2. Methods

2.1. Search strategy

We electronically searched EMBASE, PubMed, CINAHL, Cochrane Library for publications in English up to December 2018, with the following MESH terms and keywords: web learning, online learning, mobile learning, m-learning (abbreviation for mobile learning), web teaching, online teaching, mobile teaching, mixed learning, blended learning, mixed teaching, blended teaching, MOOCs, Massive Open Online Courses, blended instruction, blended instructional practice, smartphone, ipad, computer, nursing education, nurse education, education of nursing. In order to search all the relevant publications, the references of the included articles were manually searched.

2.2. Inclusion criteria and study selection

Studies were considered eligible if they met the following criteria: The participants in studies were nursing students; Blended learning was used as the only intervention in the experimental group; The blended learning is a new education method that combines face-to-face traditional learning with online learning (Kang and Seomun, 2018). The control group was traditional face-to-face learning; The studies included the quantitative results of subjective evaluation (such as learner satisfaction) or objective evaluation (such as knowledge and skill score) of learners' actual or conceptual understanding of the course; Both randomized controlled trials (RCTs) and non-RCTs including comparative study were considered for inclusion. Studies were excluded if they met the following criteria: The comparison is purely online learning rather than blended learning; Duplicate articles; Review or conference abstracts without original data; Important data is missing and could not be obtained by contacting the authors. Two investigators independently screened the studies and any disagreement was discussed by all authors until a consensus was reached.

2.3. Data extraction

The 2 authors carefully read the included articles and independently extracted the information including: first author's name, purpose of trial, year of publication, country where the intervention was conducted, study design, object of intervention, comparison intervention, outcome assessment and measurement used. If some data were missing, we contacted the original author to obtain relevant data.

2.4. Quality assessment

When evaluating the quality of the literature, 2 researchers were asked to independently evaluate the quality of studies by referring to the Cochrane Handbook for Systematic Reviews (Liberati et al., 2009). The evaluation included 6 items: randomization sequence generation, allocation concealment, blinding of participants and study personnel, blinding of outcome assessors, incomplete outcome data, selective reporting and other biases.

2.5. Statistical methods

All data were input into RevMan5.0 software for statistical analysis.

If the same measurement tool was used to measure the results, weighted mean difference (MD) was used for analysis; otherwise, standardized mean difference (SMD) was used. Relative risk (RR) was used for counting data, and 95% confidence interval (CI) was calculated for all analyses. Heterogeneity test was conducted to determine whether there was homogeneity between studies. If there was homogeneity between studies ($P > 0.1$, $I^2 < 50\%$), fixed effect model was selected. If there was heterogeneity ($P < 0.1$, $I^2 > 50\%$), the source of heterogeneity was analyzed. If the heterogeneity cannot be eliminated, the random effect model was adopted to interpret the results. Subgroup analysis was carried out on studies with heterogeneity.

3. Results

3.1. Search results

A total of 1776 studies were retrieved by databases, and we deleted 580 duplicates by double-checked electronically and manually. Among the remaining 1196 articles, only 45 articles met the inclusion criteria. For the 45 articles, nine studies claimed to be blended learning, but in fact did not combine online learning with traditional learning; seven studies' participants were not nursing students; thirteen studies were pure online learning and not blended learning; eight studies did not have control groups of traditional face-to-face learning. Finally, a total of 8 studies were included in this meta-analysis (Fig. 1).

3.2. Study quality

This review includes 8 studies published between 2007 and 2017. Six studies reported randomized methods in detail (Gagnon et al., 2013; Gerdprasert et al., 2010; Johnston et al., 2010; Kaveevivitchai et al., 2009; Lee et al., 2016; Peng et al., 2016); one study used randomization without specifying which method was used (Segal et al., 2013); the other study did not use random grouping (Salyers, 2007), because students may change the grouping due to schedule conflict, teacher preference and other factors. No studies had described random allocation concealment. Only one study described the blinding of outcome assessors. Due to the nature of the intervention, blinding of students and educators in the intervention was not feasible. In addition, all studies described incomplete outcome data, selective reporting, and high-quality methodology (Fig. 2).

3.3. Study characteristics

The eight studies were conducted in the United States (Gagnon et al., 2013; Johnston et al., 2010; Salyers, 2007), Thailand (Gerdprasert et al., 2010; Kaveevivitchai et al., 2009), China (Peng et al., 2016), South Korea (Lee et al., 2016) and Israel (Segal et al., 2013). All the studies involved a total of 574 nursing students, 277 in the intervention group and 297 in the control group. The number of participants ranged from 8 to 56. All eight studies compared blended learning with traditional learning, and although education methods of blended learning were different, they all followed the principle of combining traditional learning with online learning. Among them, three studies adopted a combination of many kinds of education resources (Gerdprasert et al., 2010; Peng et al., 2016; Salyers, 2007). The characteristics of the included studies were summarized in Table 1. Data extraction for the included studies was summarized in Table 2.

3.4. Results of meta-analysis

3.4.1. Meta-analysis on knowledge

Eight studies, including 574 nursing students, were evaluated by theoretical knowledge scores. Heterogeneity was found in the included studies ($I^2 = 90\%$, $P < 0.00001$). Subgroup analysis was required to account for the differences in interventions for blended learning. The
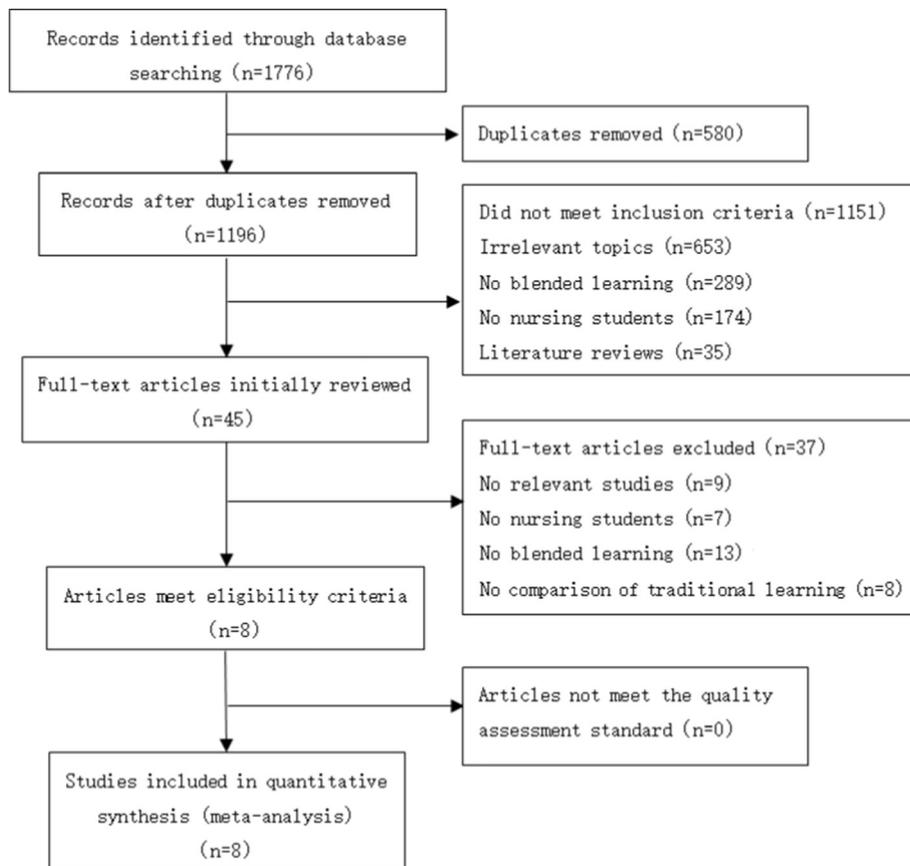
Fig. 1. Flow chart of the selection of studies included in this meta-analysis.

Fig. 2. Risk of bias summary.

results showed that blended learning had significant effects on nursing students' knowledge: Number of items in intervention ≥ 5 (SMD = 1.88, 95% CI [1.54, 2.21], P < 0.00001); Number of items in intervention < 5 (SMD = 0.25, 95% CI [0.05, 0.46], $P = 0.02$) (Fig. 3).

3.4.2. Meta-analysis on skills

Three studies (Kaveevivitchai et al., 2009; Lee et al., 2016; Salyers, 2007), including 187 nursing students, reported the outcomes of blended learning on participants' skills. Heterogeneity was found in included studies ($I^2 = 82\%$, $P = 0.003$). Excluding other reasons, the random-effect model was used to analyze the results. The results showed some improvement in skills compared with traditional learning, but there was no statistical significance (SMD = 0.58, 95% CI [-0.17, 1.32], $P = 0.13$). The sensitivity analysis of single study was carried out one by one, and single study did not change the quantity of combined effect qualitatively (Fig. 4).

3.4.3. Meta-analysis on satisfaction

Five studies (Gagnon et al., 2013; Johnston et al., 2010; Lee et al., 2016; Salyers, 2007; Segal et al., 2013) reported the effect of blended learning on participant's satisfaction. However, the data of one study (Segal et al., 2013) could not be used due to the lack of numerical data, and the remaining four studies could be used for meta-analysis (Gagnon et al., 2013; Johnston et al., 2010; Lee et al., 2016; Salyers, 2007). The four studies included 239 nursing students. Inclusion studies found low heterogeneity ($I^2 = 24\%$, P = 0.003), so the fixed-effect model was used. The results showed that blended learning could effectively improve nursing students' satisfaction, and the combined effect was statistically significant (SMD = 0.72, 95% CI [0.08, 0.59], $P = 0.01$) (Fig. 5).

Table 1
Characteristics of included studies.

First author (year)	Country	Participants	Sample size (T/C)	Intervention	Control	Outcome
Peng Xiong 2017	China	Nursing students	40/40	1. Lectures to review the principles of SPs 2. Videos to demonstrate correct SPs procedures 3. Role-playing 4. Small group discussion on site 5. Online learning group	Traditional teaching	Knowledge.
Nam 2016	South Korea	Nursing students	36/35	1. A 90-minute lecture on urinary catheterization 2. A mobile-based video	Traditional teaching	Knowledge, skills, satisfaction.
Marie 2013	United States	Nursing students	56/56	1. A face-to-face class 2. Eleven internet-based modules 3. Class discussion 4. Small-group exercises	Traditional teaching	Knowledge, satisfaction
Segal 2013	Israel	Nursing students	32/58	1. Lectures of the basic physiology 2. Online nephrology course 3. Interactive segments	Traditional teaching	Knowledge, satisfaction
Sailom 2010	Thailand	Nursing students	43/42	1. Lecture and tutorial 2. Ask questions to speak interest 3. Review knowledge with animation 4. Show graphically stages of labour 5. A video on early breast feeding 6. Interactive quizzes and exercises 7. Case scenarios	Traditional teaching	Knowledge.
Chularuk 2009	Thailand	Nursing students	40/40	1. Lecture and demonstration 2. A video demonstrating how to measure and record data 3. Simulation of experiences 4. The learners can interact with the module	Traditional teaching	Knowledge, skills
Vincent 2007	United States	Nursing students	22/14	1. Traditional lecture/demonstration 2. A web-enhanced approach to learn a 3-hour session each week 3. Refine skills with increased opportunity for feedback 4. Students can access support materials asynchronously 5. Interactive videos and other instructional media	Traditional teaching	Knowledge, skills, satisfaction
Robert 2010	United States	Nursing students	8/12	1. A face-to-face class 2. The same lecture in ipod	Traditional teaching	Knowledge, satisfaction

4. Discussion

4.1. Principal findings

This meta-analysis aimed to analyze the effects of blended learning on nursing students' knowledge, skills, and satisfaction compared to traditional education. Eight studies with 574 nursing students were included in this study. All studies regarded blended learning as the intervention group and put traditional learning as the control group. In the quality assessment, only one study did not use the random method but it explained that the reason was that students may change grouping due to schedule conflicts and teacher preferences. In addition, no

Table 2
Data extracted from included studies.

First author (year)	Sample size (T/C)	Outcome		
		Knowledge (T/C)	Skill (T/C)	Satisfaction (T/C)
Peng Xiong 2017	40/40	Mean41.28 (SD 0.93)/ Mean35.98 (SD 3.87)	/	/
Nam 2016	36/35	Mean10.44 (SD 1.76)/ Mean10.26 (SD 1.86)	Mean10.44 (SD 1.76)/ Mean10.26 (SD 1.86)	Mean7.25 (SD 1.42)/ Mean6.43 (SD1.36)
Marie 2013	56/56	Mean19.6 (SD 1.9)/ Mean19.0 (SD 2.7)	/	Mean79.5 (SD 12.2)/ Mean78.3 (SD 11.9)
Segal 2013	32/58	Mean9.6 (SD 2.57)/ Mean8.4 (SD 2.72)	/	Percentage description[a]
Sailom 2010	43/42	Mean51.00 (SD 3.34)/ Mean41.70 (SD 5.56)	/	/
Chularuk 2009	40/40	Mean18.33 (SD 1.87)/ Mean17.83 (SD 2.35)	Mean18.33 (SD 1.87)/ Mean17.83 (SD 2.35)	/
Vincent 2007	22/14	Mean92.68 (SD 5.93)/ Mean82.21 (SD 7.05)	Mean92.68 (SD 5.93)/ Mean82.21 (SD 7.05)	Mean3.5 (SD 0.65)/ Mean2.96 (SD 0.84)
Robert 2010	8/12	Mean82.75 (SD 4.69)/ Mean82.38 (SD 7.03)	/	Mean83.2 (SD 4.21)/ Mean82.42 (SD 4.54)

[a] 97% thought the course was well organized, 100% thought the teacher taught clearly and consistent, 90% thought the teacher encouraged self-thinking, 100% thought the teacher used clarifying examples, 91% thought the teaching aids helped the learning process.
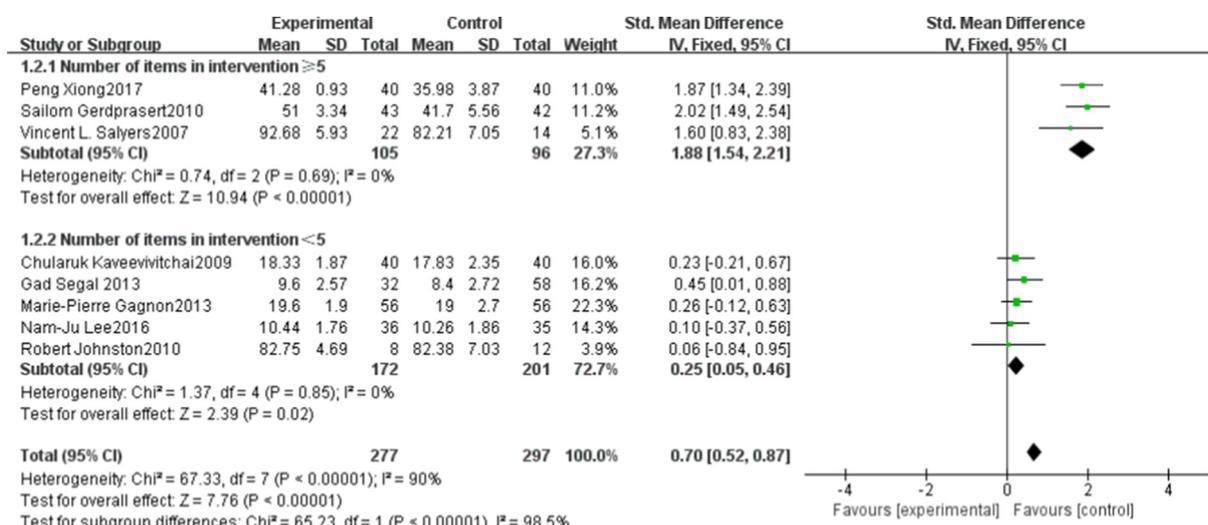
Fig. 3. Effect of blended learning on knowledge.

studies had described random allocation concealment. Only one study described the blinding of outcome assessors. Because of the particularity of blended learning, blinding of students and educators in the intervention was not feasible, which may affect the results of this meta-analysis.

Our results show that blended learning has a positive effect on the teaching of knowledge, consistent with previous studies (Peng et al., 2016). Although we found a high degree of heterogeneity of the included studies, we could not find any significant differences in the risk of bias in these studies that could explain the high heterogeneity. All participants in the included studies were enrolled nursing students with roughly the same basic information. Therefore, we used subgroup analysis to assess the cause of heterogeneity. In the eight selected articles, blended learning was compared with traditional learning, but three of them adopted a variety of blended learning interventions. Therefore, the number of interventions in blended learning was used as a classification index for subgroup analysis. We found that not only the heterogeneity was solved, but also the effects of blended learning were better with the more interventions. It has been shown that in online learning, medical students are more interested in the education model with more interaction and their scores are significantly higher than those with less interaction (Cook et al., 2006; Liu et al., 2016). There are several possible reasons for this difference: First, a rich blended learning allows the teacher to understand what knowledge nursing students have acquired before the course, so that they can determine the learning objectives and prepare appropriate course materials. Second, the discussion and case analysis are added during the learning process to strengthen the interaction between the students, and the peer effect plays a certain role (Sherman et al., 2012). Most importantly, active learning strategies are used to develop students' motivation to acquire knowledge (McLaughlin et al., 2013).

Blended learning is considered to be an effective way of learning that integrates the advantages of online and traditional learning. If we only transform the traditional learning teaching resources into a

network form, it is difficult to achieve the desired results. We are also interested in whether blended learning is more effective than traditional methods in improving the skills of nursing students. In this meta-analysis, three studies reported the impact of blended learning on skills. The results showed that there was no significant difference in skills between traditional learning and blended learning. The sensitivity analysis indicated that the results were relatively stable. Similar results were found in studies of online learning (Cook et al., 2008) and e-learning (Lahti et al., 2014). The reason may be that the nursing skills are very practical, and if there is no certain amount of practice, it will be difficult to get a qualitative improvement. In addition, since non-English articles were excluded in this analysis, our results may be affected if they were included. Therefore, the effect of blended learning on skills should be further investigated with large sample size.

We also analyzed the effectiveness of blended learning on the satisfaction of nursing students. Meta-analysis results showed that students had higher satisfaction with blended learning compared with traditional teaching, in agreement with previous studies on mobile learning and online learning (Lahti et al., 2014; McVey et al., 2009; Tsai et al., 2004). Traditional teaching methods, especially face-to-face teaching, seems to be unpopular among students (Franklin and Lee, 2014; Kong et al., 2013). It was reported that online learning is more acceptable to students because it provides more animations, video and clinical images than traditional learning (Gerdprasert et al., 2010). Although many nursing students have a positive attitude towards online learning, others argue that online learning should complement rather than replace traditional learning. They are more willing to accept the learning way of combination of online learning and traditional learning, which is called blended learning (Kelly et al., 2009). In one study (Segal et al., 2013), satisfaction was expressed as a percentage, and the satisfaction of blended learning was better than that of traditional teaching whether in curriculum arrangement, teaching objectives or teaching methods.

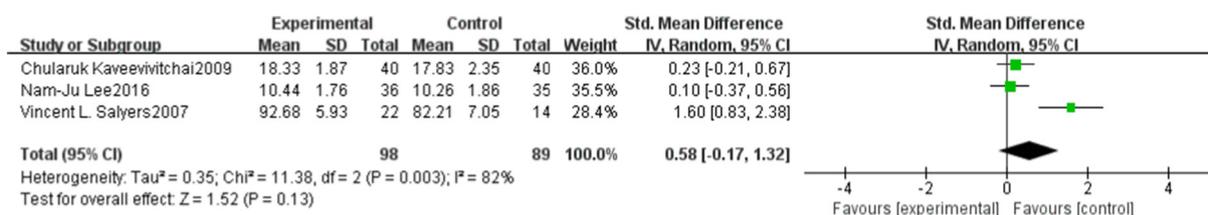With the development of disciplines and patients' increasing

Fig. 4. Effect of blended learning on skills.

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Fixed, 95% CI
Marie-Pierre Gagnon2013	79.5	12.2	56	78.3	11.9	56	48.4%	0.10 [-0.27, 0.47]
Nam-Ju Lee2016	7.25	1.42	36	6.43	1.36	35	29.4%	0.58 [0.11, 1.06]
Robert Johnston2010	83.2	4.21	8	82.42	4.54	12	8.3%	0.17 [-0.73, 1.07]
Vincent L. Salyers2007	3.5	0.65	22	2.96	0.84	14	13.9%	0.72 [0.03, 1.42]
Total (95% CI)			122			117	100.0%	0.33 [0.08, 0.59]

Heterogeneity: Chi² = 3.95, df = 3 (P = 0.27); I² = 24%
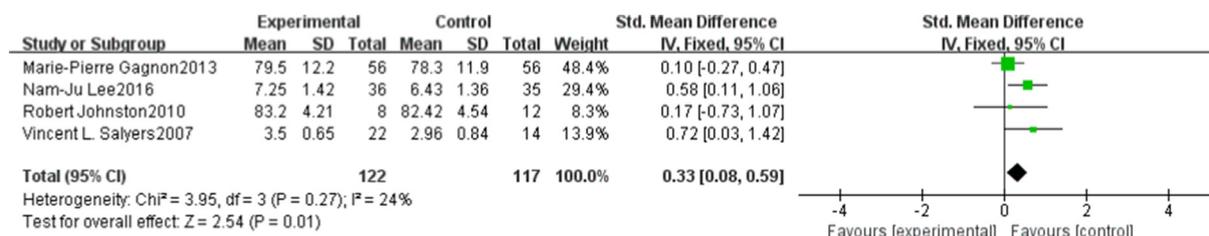Test for overall effect: Z = 2.54 (P = 0.01)

Fig. 5. Effect of blended learning on satisfaction.

demand for nursing, nurses are facing more challenges (Cui et al., 2018). Blended learning provides an important way for nursing students to learn updated nursing knowledge. In traditional teaching, students are too dependent on teachers to form the habit of acquiring knowledge actively. In the pure online teaching, the students' self-control is not strong, and they easily indulge in the network (Johnston et al., 2010). Blended learning combines traditional teaching with online learning, and not only makes it easier for nursing students to acquire knowledge, but also enables them to better complete learning tasks under the supervision of teachers.

4.2. Strengths and limitations

Our meta-analysis has some strengths. First, nurses are frontline health care workers who have the most direct contact with patients (Cole, 2009). It is very important for nursing students and patients to evaluate the effectiveness of blended learning. Second, we conducted an extensive search of blended learning, using not only the keywords of blended learning but also a series of keywords of online learning to avoid the omission of literature. However, our study has some limitations. The randomization method in some articles was not provided, so we could not determine whether the randomization was appropriate. The devices used in blended learning were different, which may have an impact on the results of meta-analysis. In addition, due to the non-English articles were excluded, which may affect the results.

5. Conclusions

This meta-analysis is the first evidence-based study comparing blended learning with traditional learning on nursing students' knowledge, skills and satisfaction. The results showed that blended learning could effectively improve the knowledge level and satisfaction of nursing students. Therefore, blended education can be used as a teaching method of nursing education in the future. However, due to the limited number of included literatures, more high-quality studies are needed to confirm our findings.

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Declaration of competing interest

None declared.

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