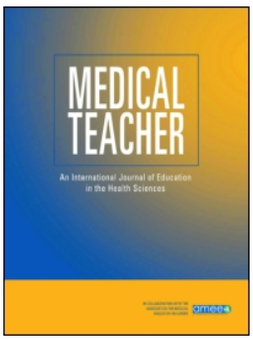

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Effects of seminar teaching method versus lecture-based learning in medical education: A meta-analysis of randomized controlled trials

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ABSTRACT

Purpose: The aim of this review is to explore the effects of the seminar teaching method versus lecture-based learning (LBL) in the education of medical students by meta-analysis.

Method: Data and information available on PubMed, Cochrane Library, EMBASE, MEDLINE, China National Knowledge Infrastructure, WanFang Data, China Science Periodical Database, and Chinese BioMedical were searched and examined from the inception up to January 2020. Randomized controlled trials (RCTs) that investigated the effects of the seminar teaching method versus LBL in medical education were included.

Results: A total of 16 RCTs were included, with a total sample size of 1122 medical students. The seminar teaching method significantly improved knowledge scores (SMD = 1.38, 95%CI 0.92–1.84; $p < 0.001$) and skill scores (SMD = 1.46, 95%CI 1.00–1.91; $p < 0.001$) and the seminar teaching method significantly improved teaching effects, including active learning ability, learning interest, scientific innovation, and independent thinking ability, expression and communication ability, clinical thinking ability, teamwork, teacher-student interaction, and classroom atmosphere.

Conclusions: This meta-analysis showed that the seminar teaching method is an effective method for improving knowledge scores, skill scores, active learning ability, student collaboration, classroom atmosphere, and interaction between teachers and students.

KEYWORDS
Lectures/large group; small group

Introduction

The seminar teaching method is a teaching model in which students work in small groups to discuss assigned questions and issues under the guidance of teachers. The underlying objective idea of the seminar teaching method is to enable students to achieve the purpose of learning by discussing and even confronting practice questions (Jaarsma et al. 2008; Dewsbury et al. 2013).

In the seminar teaching method process, students take the initiative to preview the course content, find evidence and answers to questions assigned before course, share knowledge points with peers during the course. Traditional lecture-based learning is generally considered to induce passivity and compliance as it focuses on a one-way transfer of knowledge. The seminar teaching method, on the other hand, stresses on a multi-directional interaction between teachers and students or between students (Brown and Manogue 2001; Tricio et al. 2019). Engaging in previewing and preparing for courses helps improve the ability of students for knowledge collection and active learning is improved during engaging in previewing and preparing for courses. Students develop the quality of listening, questioning scientifically, debating with evidence, and collaborating during the discussion and communications (Novak 2002; Khosa et al. 2010). The seminar teaching method can help achieve the purpose of fully mastering knowledge points and improving learning scores (Kurczek and Johnson 2014; Spruijt et al. 2015).

Practice points

- The meta-analysis revealed that the seminar teaching method was more effective in improving scores than lecture-based learning for medical students.
- There appears to be no difference in teaching basic concepts for students taught by seminar teaching methods or lecture-based learning.
- The effects of seminar teaching methods in practice courses were better than theory courses.

However, the seminar teaching method has some disadvantages, for example, it increases the learning burden, taking up too much spare time(Zhang and Shen 2011). Although the seminar teaching method has been widely used in medical education, there is no high-quality evidence like a systematic review or meta-analysis, suggesting that the seminar teaching method is superior to LBL. For these reasons Consequently, this meta-analysis aims to fill

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Supplemental data for this article can be accessed here.

this gap by comparing the effects of the seminar teaching method and LBL in medical education.

Method

This study protocol has not been previously published. This meta-analysis is based on the recommended PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) checklist guidelines (Moher et al. 2015). All analyses were based on previously published studies; thus no ethical approval and patient consent are required.

Search strategy and criteria

Two investigators (Z.H.L and C.D.X) independently searched electronic databases, including PubMed, Cochrane Library, EMBASE, and MEDLINE. Data were also retrieved from Chinese databases, including China National Knowledge Infrastructure, WanFang Data, China Science Periodical Database, and the Chinese BioMedical Literature Database. Google Scholar was screened for additional eligible studies. All databases were examined from database inception up to January 2020. Details of the search strategy are presented in Supplementary Appendix 1. The last retrieval was performed on 12 January 2020.

Randomized controlled trials investigating the effects of the seminar teaching method versus LBL in the teaching of medical students were included in this meta-analysis. The references sections of all eligible studies and previously published review articles were manually searched and inspected performed in order to identify additional studies.

References were managed using EndNote X9 software (Thomson Reuters, New York, NY). Two reviewers (Z.H.L and C.D.X) independently performed an initial screening of titles and abstracts for all the retrieved studies. Full texts were screened to identify the final eligible studies. Disagreements were reconciled through discussion among the research team (L.Q and W.X.Y).

Data extraction

The data of authors, publication date, sample size, characteristics of students, characteristics of courses, and outcomes were extracted. The primary outcomes of the meta-analysis were knowledge scores and skill scores. Secondary outcomes were the evaluation of teaching effects including the improvement of classroom atmosphere, active learning ability, interest in learning, expression and communication skills, analytical skills, teacher-student interaction, and so forth.

Assessment of risk of bias

The risk of bias for each Randomized controlled trial (RCT) was assessed by two reviewers (Z.H.L and C.D.X) based on the Cochrane Collaboration's risk of bias tool (Higgins et al. 2011). The risk of bias for each of these categories – performance, detection, attrition, reporting, and other biases were classified as high, low, or unclear risks.

Grading the quality of evidence

The quality of evidence for each outcome was rated based on criteria established by the GRADE (Grading of Recommendations Assessment, Development, and Evaluation) group. Quality of evidence was classified as very low, low, moderate, or high (Higgins et al. 2011). Any disagreement was settled through discussion among the research team.

Subgroup analysis

Subgroup analysis was planned before examining potential differences between course type (theory courses versus practice courses) and students' years of schooling (short-term program versus long-term program) in primary outcomes including knowledge scores and skill scores. The practice course was defined as clinical probation or internship. Other courses were classified as theory courses.

Statistical analysis

Review Manager (RevMan for Windows, version 5.3; Cochrane Collaboration, Oxford, UK) was used to perform all meta-analyses. The risk ratios (RR) with 95% confidence intervals (CI) were calculated for dichotomous variables. The standardized mean differences (SMD) with 95% CI were calculated for continuous variables. To facilitate meta-analysis, median and interquartile range were converted to mean and standard difference (SD) according to the Cochrane Collaboration Handbook. I^2 test and chi-square test were used to assess heterogeneity ($I^2 > 50\%$ or chi-square $P < 0.1$ indicating substantial heterogeneity). When $p > 0.10$ or $I^2 < 50\%$, a fixed-effects analysis model or a random-effects analysis model was used. $p < 0.05$ was considered statistically significant.

Result

Search result

Through the initial search of electronic databases, including PubMed, Cochrane Library, EMBASE, MEDLINE, China National Knowledge Infrastructure, WanFang Data, China Science Periodical Database, and the Chinese BioMedical Literature Database, 1185 records were identified. After duplicates were removed, the titles and abstracts of 858 unique records were screened. Out of the 858 records, 32 full-texts were assessed for eligibility. Ultimately, 16 studies (Zheng 2011; He et al. 2013; Liu et al. 2013; Cao et al. 2015; Chen et al. 2015; Cheng et al. 2015; Meng and Lu 2015; Zhang W et al. 2015; Zhang Y et al. 2015; Peine et al. 2016; Peng et al. 2016; Xu et al. 2016; Ji and Luo 2017; Li et al. 2017; Chen et al. 2019; Wang et al. 2019) met the inclusion criteria with a total of 1122 medical students included in the final analysis. A Prisma-flow diagram of the literature search and the exclusion criteria is depicted in Figure 1.

Study characteristics

Sixteen RCTs representing 1122 medical students (561 students each in seminar teaching method group and LBL group) were included in the final meta-analysis. All included studies were published between 2011 and 2019. The sample

size of the included studies ranged from 28 to 240 medical students. One of these studies (Peine et al. 2016) was published in English and the other 15 studies were published in Chinese. The types of courses included in the studies were pharmacology, medicine, surgery, gynecology and obstetrics, pediatrics, anesthesiology, and so forth. There were seven RCTs (Zheng 2011; Liu et al. 2013; Chen et al. 2015; Zhang W et al. 2015; Zhang Y et al. 2015; Peine et al. 2016; Wang et al. 2019) which dealt with courses on theory courses, and nine RCTs (He et al. 2013; Cao et al. 2015; Cheng et al. 2015; Meng and Lu 2015; Peng et al. 2016; Xu et al. 2016; Ji and Luo 2017; Li et al. 2017; Chen et al. 2019) which focused on practice courses. Table 1 shows the baseline characteristics of all the included studies (Table 1).

Risk of bias and quality of evidence

The risk of bias was summarized by the Cochrane Risk of Bias tool. Random sequence generation method of low risk was conducted in 3 studies (Liu et al. 2013; Peine et al. 2016; Li et al. 2017). Two studies (Zhang W et al. 2015; Peng et al. 2016) conducted a high-risk random sequence generation

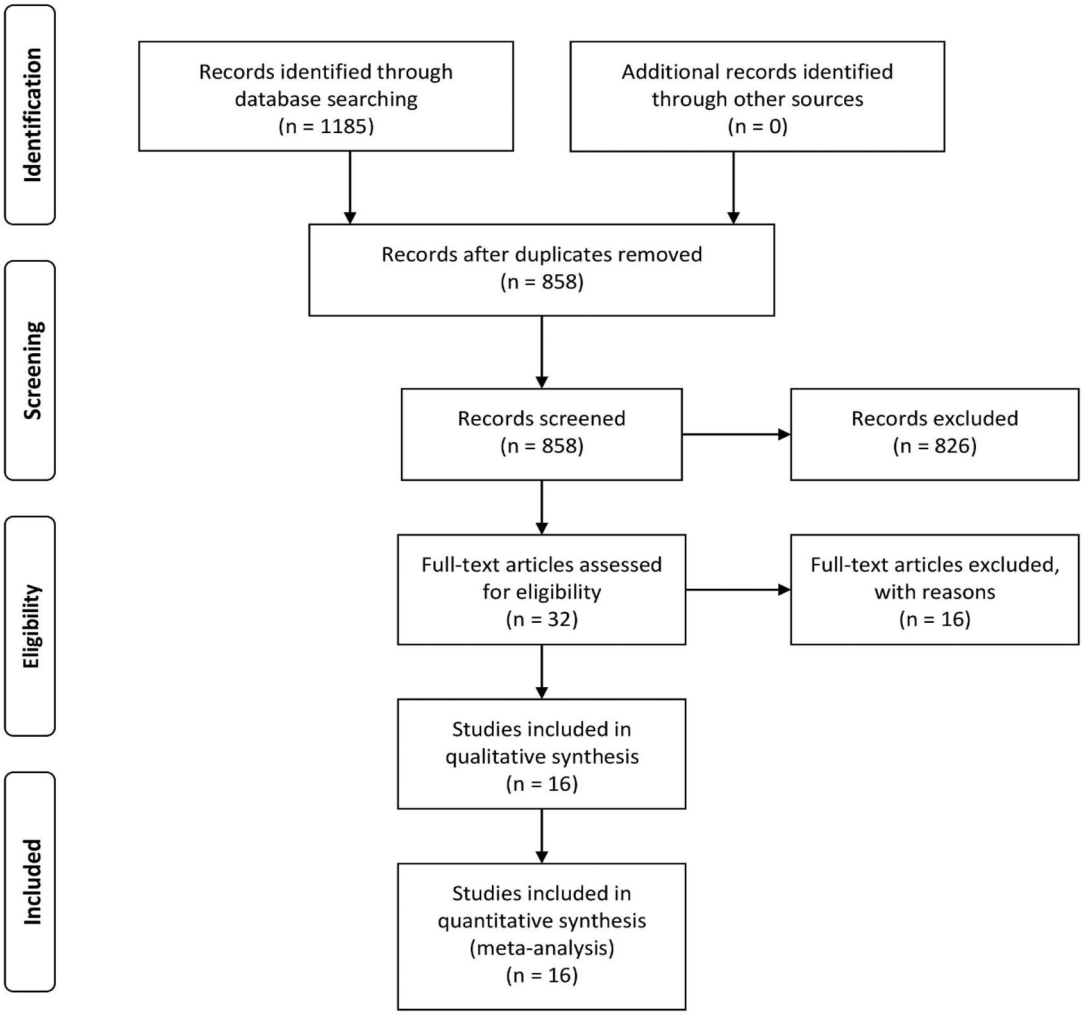

Figure 1. Prisma-flow diagram for the literature search and exclusion criteria.

Table 1. The detailed baseline characteristics of all included studies.

Study	Publication time	No. of seminar	No. of LBL	Students	Course name	Course type	Outcomes
Zheng et al.	2011	30	30	Undergraduate	Plastic surgery	Theory course	Knowledge and skill scores, evaluation of teaching effects
Liu et al.	2013	50	50	Undergraduate	Obstetrics and gynecology	Theory course	
He et al.	2013	15	15	Undergraduate	Urology	Practice course	
ZhangY et al.	2015	30	30	Undergraduate	Anesthesiology	Theory course	
ZhangW et al.	2015	24	24	7-year-program undergraduate	Medical function	Theory course	
Meng et al.	2015	14	14	7-year-program undergraduate	Rhheumum immunology	Practice course	
Ji et al.	2015	42	42	Undergraduate	Rhheumum immunology	Practice course	
Cheng et al.	2015	23	23	Undergraduate	General surgery	Practice course	
Chen et al.	2015	30	30	Undergraduate	Neurology	Theory course	
Cao et al.	2015	20	20	8-year-program undergraduate	Pediatrics	Practice course	
Xu et al.	2016	15	15	Undergraduate	Urology	Practice course	
Peine et al.	2016	52	52	Undergraduate	Pharmacology	Theory course	
Peng et al.	2016	30	30	Undergraduate	Pediatrics	Practice course	
Li et al.	2017	20	20	Undergraduate	Vascular Surgery	Practice course	
Chen et al.	2019	46	46	Undergraduate	Pediatrics	Practice course	
Wang et al.	2019	120	120	Undergraduate	Radiography	Theory course	

No.: number; LBL: lecture-based learning.

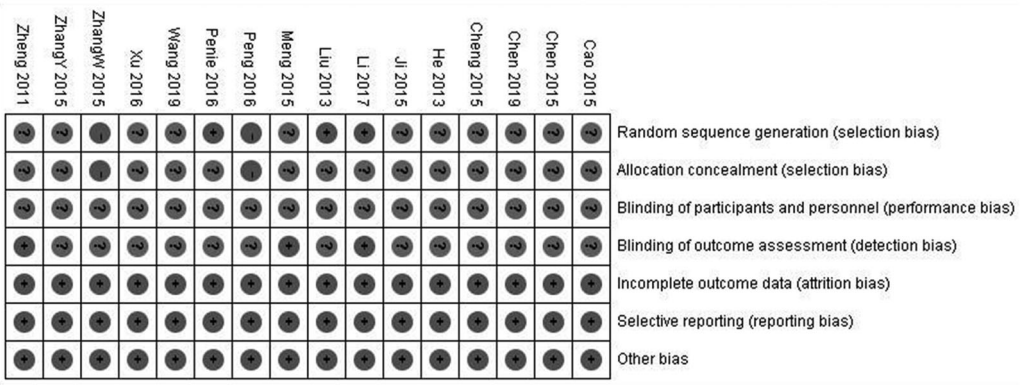

Figure 2. Risk of bias summary for each included study.

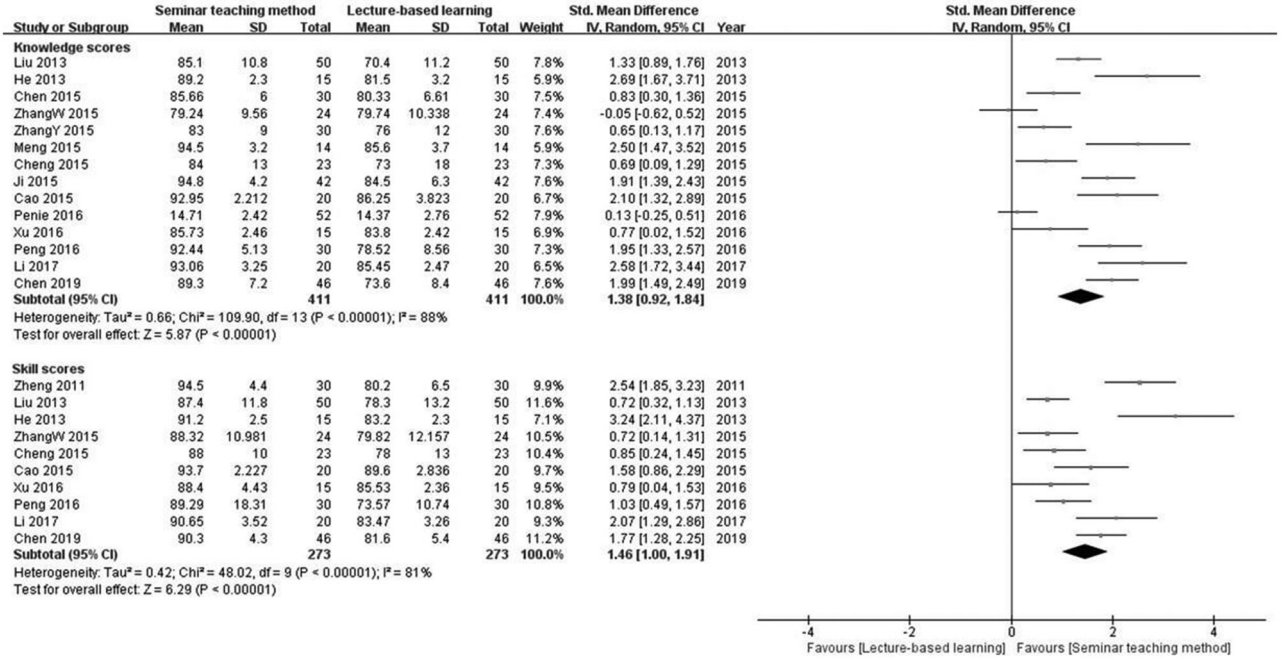

Figure 3. Forest plot of knowledge scores and skill scores.

method thus the risk of allocation concealment of these. Two studies were judged as high risk. Others did not clearly report the method of random sequence generation and allocation concealment. None of the other studies reported blinding method. Three studies (Zheng 2011; Meng and Lu 2015; Li et al. 2017) conducted blinding of outcome assessment. All studies were of low risk in incomplete outcome data, selective reporting, and other bias. The risk of bias summary of each of the studies is shown in Figure 2. As a result of high heterogeneity and unclear statement of randomized and blinding methods in most of the included studies, the GRADE quality of the result of this meta-analysis was classified as low. The GRADE quality of evidence is presented in Supplementary Appendix 2.

Meta-analysis

Knowledge scores and skill scores

Primary outcomes included knowledge scores and skill scores. Fourteen studies (He et al. 2013; Liu et al. 2013; Cao et al. 2015; Chen et al. 2015; Cheng et al. 2015; Meng and Lu 2015; Zhang W et al. 2015; Zhang Y et al. 2015; Peine et al. 2016; Peng et al. 2016; Xu et al. 2016; Ji and Luo 2017; Li et al. 2017; Chen et al. 2019) reported relevant data of knowledge scores (411 students each in the seminar and LBL groups). Meta-analysis with a random-effects model showed that the seminar teaching method significantly increased knowledge scores compared with LBL (SMD = 1.38, 95%CI 0.92–1.84; $p < 0.001$; $I^2 = 88\%$). Ten studies (Zheng 2011; He et al. 2013; Liu et al. 2013; Cao et al. 2015; Cheng et al. 2015; Zhang W et al. 2015; Peng et al. 2016; Xu et al. 2016; Li et al. 2017; Chen et al. 2019) reported skill scores (273 students each in the seminar and LBL groups). This meta-analysis found that skill scores were significantly increased through the seminar teaching method compared with LBL (SMD = 1.46, 95%CI 1.00–1.91; $p < 0.001$; I^2=81%). The forest plot of knowledge scores and skill scores are shown in Figure 3. An assessment of the publication bias is shown in Figure 4 by using funnel plots of knowledge scores and skill scores.

Evaluation of teaching effects

Evaluation of teaching effects consisted of 12 items, including the improvement of classroom atmosphere, improvement of active learning ability, improvement of learning interest, improvement of expression and communication ability, improvement of analytical ability, improvement of teamwork, improvement of teacher-student interaction, clarity of learning purposes, cultivation of clinical thinking ability, mastery of basic concepts, improvement of scientific innovation ability

and development of independent thinking ability. According to the meta-analysis result of evaluating teaching effects, compared with LBL, the seminar teaching method significantly improved all evaluation items except mastery of basic concepts. The detailed meta-analysis result of evaluating teaching effects is shown in Figure 5.

Subgroup analysis

Subgroup analysis revealed that the seminar teaching method significantly improved knowledge scores of practice courses but did not have any notable effects on theory courses ($p = 0.002$; Table 2). However, no difference was observed in skill scores between theory courses and practice courses ($p = 0.68$). No significant differences were found in knowledge scores ($p = 0.89$) and skill scores ($p = 0.40$) between short-term program students and long-term program students (Table 2).

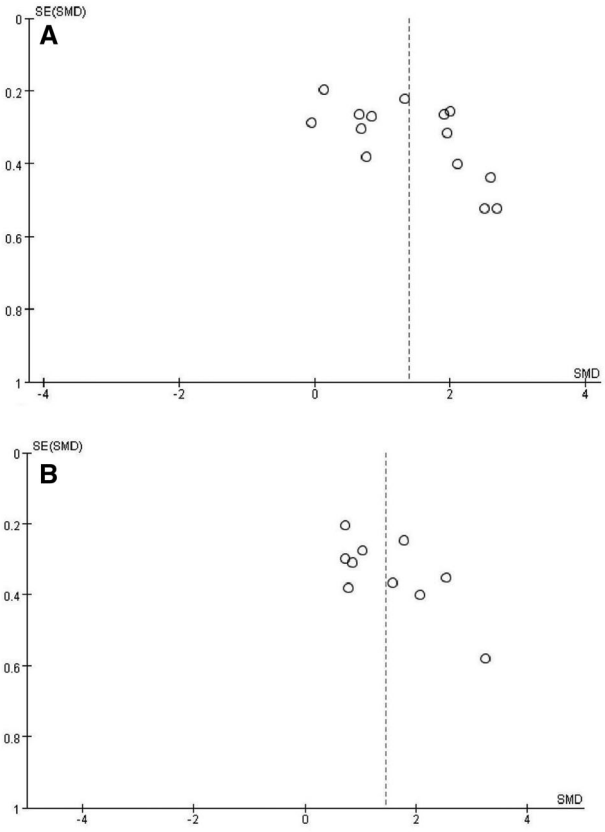

Figure 4. Funnel plot of knowledge scores (A) and skill scores (B).

Discussion

Our meta-analysis primarily found that the seminar teaching method could significantly improve knowledge scores and skill scores compared with LBL. Except for mastery of the basic concept, the seminar teaching method could also significantly improve the evaluation of teaching effects including active learning ability, learning interest, scientific innovation, and independent thinking ability, expression and communication ability, clinical thinking ability, teamwork, teacher-student interaction, and classroom atmosphere.

The score is not only an important and direct reference for evaluating knowledge acquisition of students but also an important parameter for measuring educational quality. Our meta-analysis found students' knowledge and skill scores were significantly improved through the seminar teaching method. In addition, students' learning interests, active learning ability, and thinking and comprehensive ability were considerably improved. The seminar teaching method pays more attention to the students' initiative role in the teaching process and fully mobilizes their initiative in the learning process (Brunton et al. 2000). It also encourages independent learning and thinking on the part of the students so as to enable them to tackle scientific questions and focus on their ability to solve practical problems by consulting literature and discussing among small groups (Morgan 2019). Collaboration ability, classroom atmosphere, expression and communication ability, and interaction between teachers and students were significantly improved through the seminar teaching method. By properly collaborating on teaching tasks, engaging in information collection, and participating in communication and discussion in class, all seminar members can contribute to the teaching process. This helps promote the spirit of unity and cooperation among students, realize the importance of sharing and teamwork, and ultimately improve the team collaboration ability of students (Jaarsma et al. 2009; Caratelli et al. 2020). Unlike the traditional practice of simply listening to the instructor, the seminar teaching method focuses on student-oriented discussion under the guidance of teachers. When students were given the opportunity to explore the seminar content with peers, their expression and communication ability were greatly improved, and the atmosphere of the class is enlivened (Spruijt et al. 2012). In addition, students' active participation in the learning, teachers offered comments and guidance to the students during the discussion, which made the communication between students and

Evaluation of teaching effects	No. of studies	No. of seminar	No. of LBL	SMD (95% CI)	P value	I²
Improvement of class atmosphere	8	186	186	1.88 [1.32, 2.44]	< 0.001	79%
Improvement of active learning ability	6	136	136	1.10 [0.70, 1.51]	< 0.001	56%
Improvement of learning interest	6	151	151	3.42 [1.74, 5.11]	< 0.001	95%
Improvement of expression and communication ability	5	121	121	3.35 [1.54, 5.15]	< 0.001	95%
Improvement of comprehensive analytical ability	5	131	131	2.30 [1.64, 2.96]	< 0.001	75%
Improvement of teamwork	4	85	85	1.10 [0.60, 1.60]	< 0.001	56%
Improvement of teacher-student interaction	4	85	85	1.11 [0.78, 1.44]	< 0.001	0%
Clearness of learning purposes	4	101	101	1.62 [0.86, 2.38]	< 0.001	80%
Cultivation of clinical thinking ability	4	101	101	2.29 [0.82, 3.75]	0.002	93%
Master of basic concepts	3	71	71	0.39 [-0.20, 0.97]	0.19	60%
Improvement of scientific research and innovation ability	3	71	71	2.43 [0.92, 3.95]	0.002	89%
Development of independent thinking ability	3	71	71	2.99 [2.25, 3.72]	< 0.001	49%

No. = number; LBL = Lecture-based learning; SMD = standardized mean differences; CI = confidence interval .

Figure 5. Meta-analysis result of evaluation of teaching effects.

Table 2. Result of subgroup analysis.

					Incidence					Subgroup differences		
Outcomes	Subgroups	Studies	No. of Seminar	No. of LBL	SMD	95%CI	*p*	I^2	Model	Chi^2	*p*	I^2
Knowledge scores	Theory courses	5	186	186	0.58	[0.08,1.09]	0.02	82%	Random	13.50	<0.001	92.6%
	Practice courses	9	225	225	1.85	[1.40, 2.31]	<0.001	73%	Random			
	Long-term	3	58	58	1.48	[−0.22, 3.18]	0.09	93%	Random	0.02	0.89	0%
	Short-term	12	353	353	1.36	[0.88, 1.85]	<0.001	88%	Random			
Skill scores	Theory courses	3	104	104	1.30	[0.25, 2.35]	0.02	91%	Random	0.15	0.70	0%
	Practice courses	7	169	169	1.53	[1.03, 2.03]	<0.001	74%	Random			
	Long-term	2	44	44	1.12	[0.29, 1.96]	0.008	69%	Random	0.71	0.40	0%
	Short-term	8	229	229	1.55	[1.01, 2.10]	<0.001	84%	Random			

No.: number; LBL: lecture-based learning; SMD: standardized mean differences; CI: confidence interval.

teachers more frequent and effective and enhanced the relationship between them (Spruijt et al. 2013).

However, some studies reported that LBL was as equally effective as, or even more effective than the seminar teaching method. Thomas et al. (2017) found that lectures as well as seminars could increase students' knowledge. In a prospective study carried out by Dawane et al. (2014), the seminar was found to be less effective in increasing the test scores when compared with tutorials and case studies. They also observed that students were not very fond of the seminar teaching method compared with tutorials and case studies. Malhotra and Khati (2013) reported that both the performance and satisfaction of students improved to a great extent with traditional didactic lectures than with student-led seminars on a common topic. It is worth mentioning that those studies which concluded that the seminar teaching method was not superior to LBL were mainly carried out in Eastern countries like India. Unlike Western countries where the seminar method has been employed for centuries, the seminar teaching method is just emerging in Eastern countries like China and India. Brown and Manogue (2001) stated that all kinds of teaching methods should be stable phenomena in practice. The quality of seminar teaching methods in Eastern countries is unstable and unsupervised, and as a result, the teaching effects and satisfaction decrease.

Our research found that the seminar teaching method was not superior to LBL in teaching basic concepts. Furthermore, subgroup analysis revealed that the improvement of knowledge scores of practice courses was significantly better than that of theory courses with the seminar teaching method versus LBL. These findings might infer that the seminar teaching method does not have a superior effect on theory knowledge when compared with LBL. Xu et al. (2016) reported that the application of seminar teaching methods in abstract knowledge undermined the ability of students to comprehend, which could consequently dampen their interest in learning. This was seconded by Spruijt et al. (2015), in crossover research, in which they found that one of the most important factors influencing seminar academic achievement was seminar content. In medical education, the theory of knowledge is usually difficult to understand. Compared with traditional efficient lectures, the seminar teaching method leaves the task of learning mostly to the students themselves. When the seminar teaching method was applied to the elusive theory content, students found it difficult to comprehend large amounts of complex content and extract the right knowledge (Tricio et al. 2019). This method might also demotivate students and reduce their enthusiasm for learning, occupy too much spare time, cause negative emotion and anxiety, and eventually realize the opposite effect (Zhang and Shen 2011; Kilgour et al. 2016). This meta-analysis found that, on the contrary, practice courses were usually easier to understand and operate. The effect of seminar teaching methods on practice courses was better than on theory courses.

In order to improve the drawbacks of the seminar teaching method, some researchers opined that the seminar teaching method combined with case-based learning (CBL) could prove fruitful(Chun et al. 2019). Through independently reviewing cases, giving diagnosis and treatment suggestions, discussing and reporting in group, and offering advice to peers, students could consolidate basic knowledge and benefit from the seminar teaching method (Luo et al. 2017). However, the effects of combining seminar teaching methods with CBL are requiring investigation in future studies.

There were several limitations to this meta-analysis. First, course content, the difficulty of examination, duration of courses, and preparation of teachers and students were different, which might have led to heterogeneity in the evaluation results. Second, the quality of methodologies employed in the included studies was not high which consequently might have caused bias in the result of this meta-analysis. Third, there are variations within lecture and seminar methods that can affect meta-analysis. A lecturer may use a seminar to predominantly lecture and might use a lecture to provoke large group discussions. All of these may have contributed to the low score on GRADE. Last, the sample size of each included study was small; hence, our meta-analysis might be subjected to small study effect bias. In summary, the results of this meta-analysis should be interpreted with caution. In order to overcome these limitations, high-quality RCTs with large sample size are recommended for future studies.

Conclusion

Our study showed that the seminar teaching method is a more effective method for medical education compared with LBL. The seminar teaching method not only improved knowledge scores and skill scores but also improved active learning ability, student collaboration, classroom atmosphere, and interaction between teachers and students. However, even though the seminar teaching method offered significant advantages in different teaching aspects, it did not show any notable improvement over LBL in teaching basic concepts. The seminar teaching method significantly improved knowledge scores of practice courses but did not have any substantial effects on theory courses.

Acknowledgment

Useful suggestions given by professors of the Chinese Cochrane Center are acknowledged.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

Glossary

The seminar teaching method: Is a teaching model in which students work in small groups to discuss assigned questions and issues under the guidance of teachers.

Notes on Contributors

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