SYSTEMATIC REVIEW

Systematically evaluate the effect of problem-based learning method in the teaching of epidemiology and health statistics in China

Xiangyuan Yu, Linyuan Qin, Gongchen Huang, Xiao He

Abstract

Objective: To systematically evaluate the application of problem-based learning teaching in medical institutions.

Methods: The systematic review was conducted in China following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, and comprised search for relevant studies on July 31, 2020, of the China National Knowledge Infrastructure, Wanfang, China Biology Medicine disc, Web of Science, National Center for Biotechnology Information, Excerpta Medica Database and PubMed databases. Quality of the included studies was assessed as adequate, uncertain or inadequate based on the Cochrane Handbook for Systematic Reviews of Interventions. The teaching effects was evaluated using relative risk or standardised mean difference along with their corresponding 95% confidence intervals.

Results: There were 3,447 students the 20 studies analysed; 1,681(48.8%) in problem-based learning group A and 1,766(51.2%) in lecture-based learning group B. Group A showed improved students' test scores, learning interest, self-learning ability and collaboration skills ($p<0.05$).

Conclusion: Problem-based learning teaching method showed advantages in terms of improvement in students' professional knowledge and key learning skills.

Keywords: Problem-based learning, Epidemiology, Statistics, Effect, Systematic evaluation. (JPMA 73: 1462; 2023)

DOI: https://doi.org/10.47391/JPMA.6676

Submission completion date: 28-06-2022 **- Acceptance date:** 06-02-2023

Introduction

[2]It is necessary for medical students to master the principles of Epidemiology and Statistics to critically evaluate medical literature. However, these subjects have traditionally been difficult to teach because students often lack learning motivation in the course content and teaching model, and may not learn effectively.[1] Therefore, reformation of the teaching methods is still in the process of evolution. So far, lecture-based learning (LBL), case-based learning (CBL), flipped classroom, problem-based learning (PBL) and team-based learning (TBL) methods, among others, have been applied to the teaching of Epidemiology and Health Statistics in Chinese medical institutions.[2,3]

The LBL method, as one of the traditional teaching methods, has been used in colleges for long. It conveys a large amount of information, plays an all-round role in education, updates content quickly and has strong controllability. However, due to lack of communication between teachers and students and the disconnection between teaching and learning, it is not conducive to giving full play to students' learning initiative and stimulating students' thinking ability to some extent. LBL is often teacher-centred and students are in a passive receiving state. In contrast, PBL often takes a specific problem as a context for students to acquire professional knowledge or skills about.[4] PBL is a student-centred model, emphasises students' initiative in the learning process. It was first implemented in the mid-1960s with the development of innovation in educational methods, and it became an educational model that has been in use today internationally.[5] PBL has been applied to medical school curricula in China. Some teaching practice shows self-directed learning skills, better cooperation capability, more enjoyable and motivational studying format and improved communication compared to traditional teaching methods.[4,6] However, there are also studies indicating that PBL is not better than the traditional approaches with respect to the teaching effect.[7,8] Since the 1980s, PBL has been widely introduced in medical institutions of China both in theoretical and clinical courses.[9] However, the effectiveness of PBL application in Epidemiology and Health Statistics courses remains unclear. The current systematic review was planned to clarify the different effects of PBL and LBL on students' test scores, learning interest, self-learning ability and collaboration skills in Epidemiology and Health Statistics courses. Considering the differences in educational systems as well as ethnic and cultural backgrounds which may affect teaching outcomes, the review was restricted to Chinese medical students studying under the Chinese educational system to evaluate

Guangxi Key Laboratory of Environmental Exposomics, School of Public Health, Guilin Medical University, Guilin, China.

Correspondence: Xiangyuan Yu. e-mail: 1146344184@qq.com

ORCID ID. 0000-0002-7675-4103

the effectiveness of PBL in a uniform setting.

Materials and Methods

The systematic review was conducted in China following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[10] and comprised search for relevant studies on July 31, 2020, of the China National Knowledge Infrastructure (CNKI), Wanfang, China Biology Medicine disc (CBMdisc), Web of Science, National Center for Biotechnology Information (NCBI), Excerpta Medica Database (EMBASE) and PubMed databases. In addition, manual supplementary search through the reference lists of potentially selected studies was also carried out. The search key words included "epidemiology" or "health statistics", "problem-based learning" or "learning based on problems" or "project-based learning", "lecture-based learning", and "teaching effect".

Two reviewers conducted the search independently and resolved any discrepancies in their selections through discussion. The studies included were related to PBL teaching of Epidemiology or Health Statistics courses at the undergraduate level in Chinese medical academic institutions; had a PBL intervention group as well as an LBL control group; included examination scores, learning interest, self-learning ability and collaboration skills as observed variables; and were published in Chinese or English languages. Commentaries and studies not dealing with the specific variables about courses of interest, or republished reports were excluded.

After the two researchers agreed on the inclusion parameters, basic information was collected and collated, including the author, publication time, sample size of PBL and LBL groups, characteristics of the subjects, and the observed outcome variables.

The quality of the studies was assessed as adequate, uncertain or inadequate based on the general sources of bias described in the Cochrane Handbook for Systematic Reviews of Interventions.[11] The items checked were:Whether the object of study is randomly assigned; Whether used allocation concealment correctly; Whether blinding method is used; Whether the selective data is complete and true; Whether incomplete outcome data is reported; Whether there are other biases to evaluate the risk of literature bias.

Analysis of data heterogeneity as well as meta-analysis was done using Stata 12.0. Data was subjected to relative risk (RR) or standardised mean difference (SMD) evaluations with their corresponding 95% confidence interval (CIs). Two-sided $p<0.05$ was considered significant for meta-analysis. Heterogeneity across the studies was assessed using the Q test, and was considered significant at $p<0.1$. A fixed-effects model was used to calculate the pooled effects if heterogeneity was not significant, otherwise, the random-effects model was adopted. If significant heterogeneity was observed, sensitivity analysis was performed to assess whether the results were reversed. Begg's test was used to assess publication bias and $p<0.05$ was considered an indication for the potential presence of publication bias. [12]

Results

Of the 20 studies reviewed, 11(55%) related to Epidemiology and 9(45%) to health statistics (Figure 1). Of the total 3,447 students in the included studies, 1,681(48.8%) were in PBL group A and 1,766(51.2%) were in LBL group B. The studies were published in the Chinese language between 2009 and 2017[13-32] (Table 1).

The PBL group showed improved students' test scores, learning interest, self-learning ability and collaboration skills in students of both Epidemiology and Health Statistics courses (Table 2, Figure 2).

Sensitivity analyses showed that stability of the meta-analyses as the results remained unchanged when any item was removed from the model, stressing that there was no single study that dramatically influenced the pooled results (Figure 3).

There was no statistically significant evidence of publication bias in the pooled analyses related to test scores ($p=0.65$), learning interest ($p=0.107$) and self-

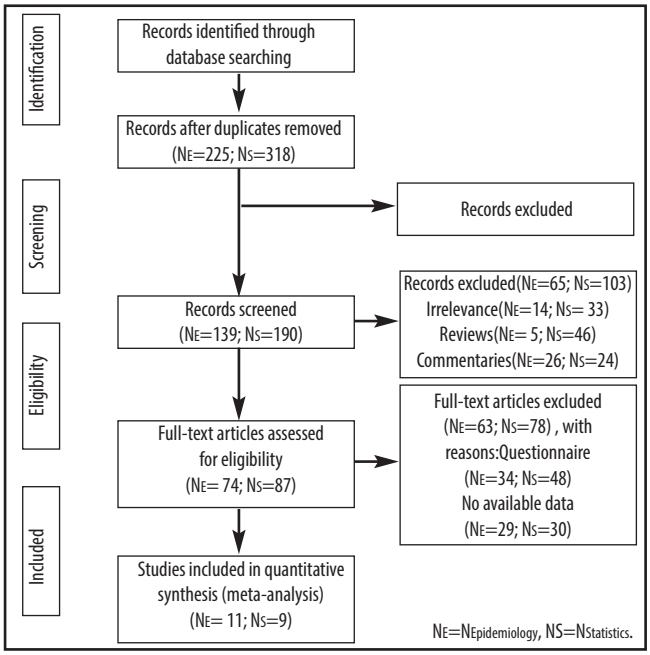


Figure-1: Flowchart of the systematic review.

Table-1: Characteristics of the studies reviewed.

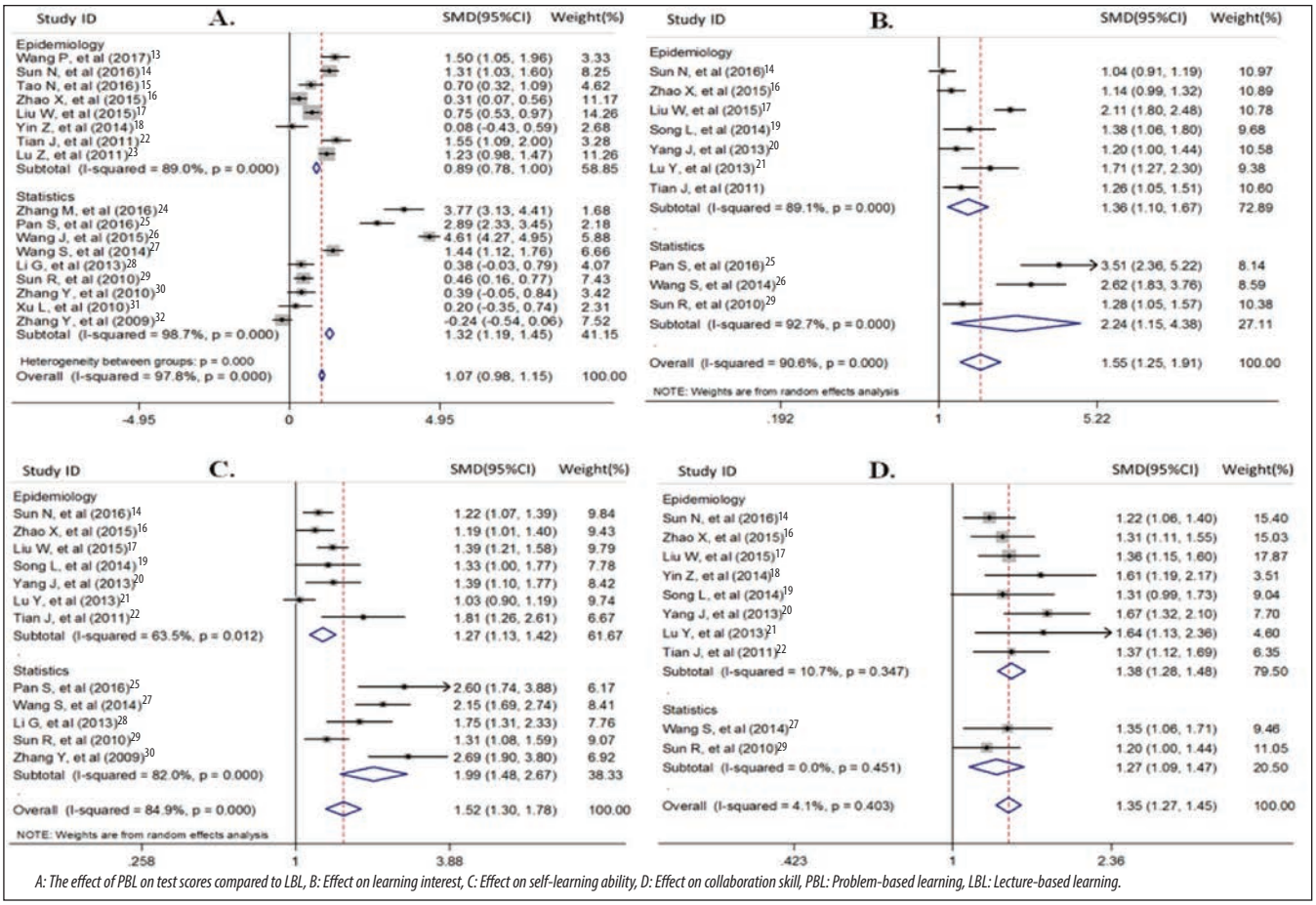
Study	Year	Study type	No. of PBL	No. of LBL	Matched	Course	Outcome assessment
Wang P, et al[13]	2017	RCT	48	48	Age, Sex, CEES, Grade	Epidemiology	T
Sun N, et al[14]	2016	RCT	105	121	Age, Sex, CEES, Grade	Epidemiology	T, L, S, C
Tao N, et al[15]	2016	RCT	50	61	Age, Sex, Grade	Epidemiology	T
Zhao X, et al[16]	2015	RCT	149	110	Age, Sex, CEES, Grade	Epidemiology	T, L, S, C
Liu W, et al[17]	2015	RCT	155	190	Age, Sex, Grade	Epidemiology	T, L, S, C
Yin Z, et al[18]	2014	RCT	30	30	Age, Sex, CEES, Grade	Epidemiology	T, C
Song L, et al[19]	2014	RCT	132	90	Grade	Epidemiology	L, S, C
Yang J, et al[20]	2013	RCT	75	77	Age, Sex, Grade	Epidemiology	L, S, C
Lu Y, et al[21]	2013	RCT	60	62	Age, Sex, Grade	Epidemiology	L, S, C
Tian J, et al[22]	2011	RCT	46	50	Age, Sex, Grade	Epidemiology	T, L, S, C
Lu Z, et al[23]	2011	RCT	150	150	Age, Sex, CEES, Grade	Epidemiology	T
Zhang M, et al[24]	2016	RCT	51	55	Age, Sex, Grade	Statistics	T
Pan S, et al[25]	2016	RCT	30	85	-	Statistics	T, L, S
Wang J, et al[26]	2015	RCT	216	268	Age, Sex, Grade	Statistics	T
Wang S, et al[27]	2014	RCT	95	93	Sex, Grade	Statistics	T, L, S, C
Li G, et al[28]	2013	RCT	45	48	Age, Grade	Statistics	T, S
Sun R, et al[29]	2010	RCT	86	85	Age, Sex, Grade	Statistics	T, L, S, C
Zhang Y, et al[30]	2010	RCT	39	39	-	Statistics	T
Xu L, et al[31]	2010	RCT	26	26	Age, Grade	Statistics	T
Zhang Y, et al[32]	2009	RCT	93	78	Sex, Grade	Statistics	T, S

RCT: Randomised controlled trial, PBL: Problem-based learning, LBL: Lecture-based learning, CEES: College entrance exam scores, T: Test scores, L: Learning interest, S: Self-learning ability, C: Collaboration skills.

learning ability (p=0.086). The only exception was collaboration skills (p=0.020). After removing one study[22] the value stood at p=0.108, indicating that the data may be one of the main sources of the detected heterogeneity in collaboration skill analysis.

Discussion

Epidemiology and Health Statistics are both application-oriented disciplines that play an important role in guiding scientific research. For a long time, LBL teaching mode has basically satisfied the needs of most curriculum learning in medical schools, including Epidemiology and



A: The effect of PBL on test scores compared to LBL, B: Effect on learning interest, C: Effect on self-learning ability, D: Effect on collaboration skill, PBL: Problem-based learning, LBL: Lecture-based learning.

Figure-2: Forest plot for the effect evaluation of PBL teaching compared to LBL in Epidemiology and Health Statistics.

Health Statistics, but LBL teaching has presented some problems as well, that the PBL teaching model has tried to address.[33] PBL is defined as a real-world and student-centred teaching method, which was first presented in 1969 at McMaster University in Canada. However, the application effect of this teaching method in China is still in a state of uncertainty.[34]

The current meta-analysis indicated that compared to LBL teaching method, PBL showed superiority in terms of students' test scores, learning interests, self-learning ability and collaboration skills in Epidemiology and Health Statistics courses. The finding is consistent with earlier reports related to pharmacology, Paediatrics, gynecology and obstetrics.[35-37] To our knowledge, the current meta-analysis is the first to assess PBL utility in Epidemiology and Health Statistics courses in China. The PBL model's utility in Epidemiology courses has earlier been established in non-Chinese settings.[38]

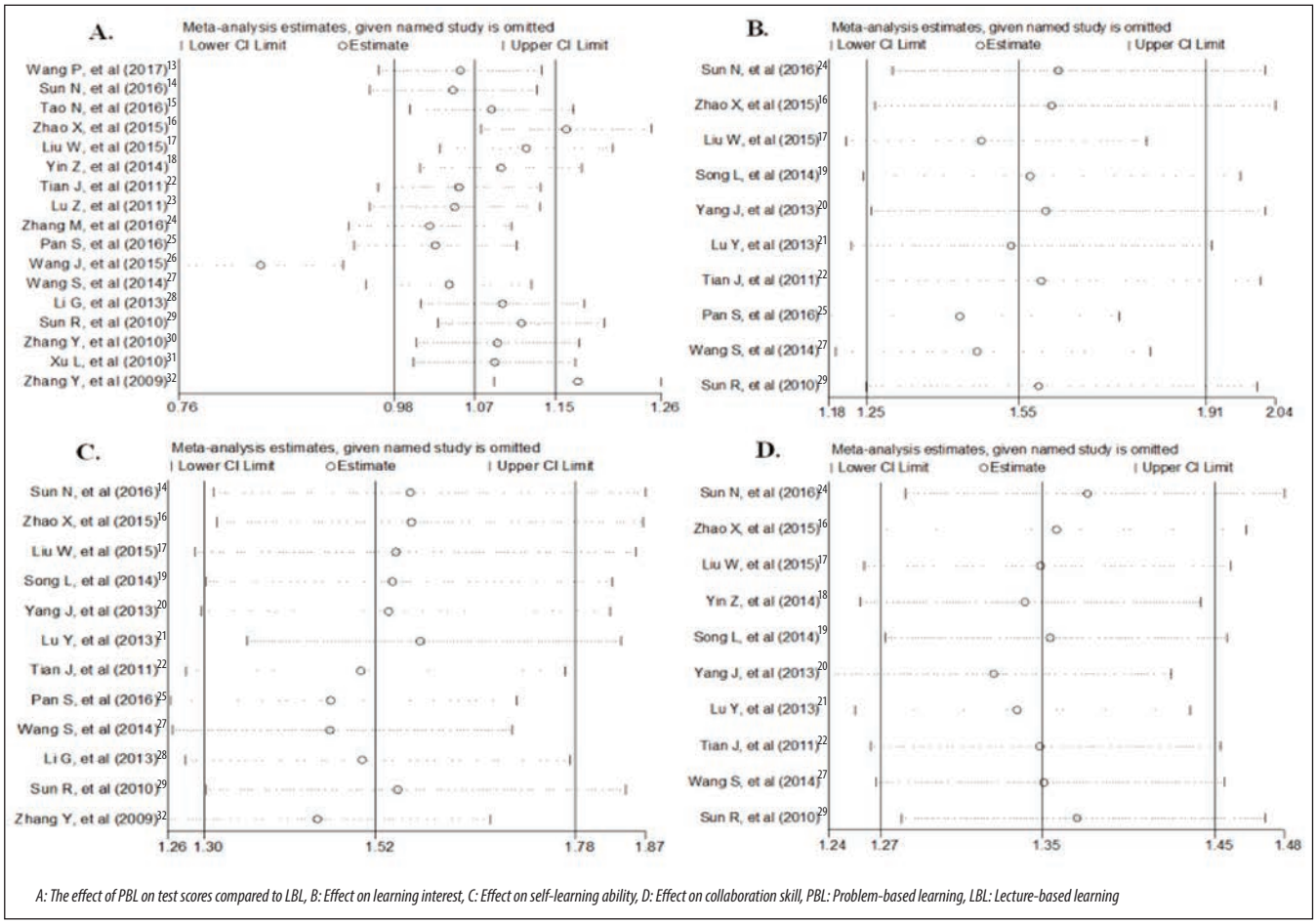
Table-2: Evaluation of PBL application in Epidemiology and Statistics courses.

Variables	No. of studies	SMD/RR (95%CI)	*p*-value	P_{Het}	I^2
Epidemiology course	11				
Test scores	8	0.89(0.78-1.00)	<0.001	89.0	<0.001
Learning interest	7	1.36(1.10-1.67)	<0.001	89.1	<0.001
Self-learning ability	7	1.27(1.13-1.42)	<0.001	63.5	0.012
Collaboration skills	8	1.37(1.27-1.48)	<0.001	10.7	0.347
Statistics course	9				
Test scores	9	1.32(1.19-1.45)	<0.001	98.7	<0.001
Learning interest	3	2.24(1.15-4.38)	0.001	92.7	<0.001
Self-learning ability	5	1.99(1.48-2.67)	<0.001	82.0	<0.001
Collaboration skills	2	1.25(1.09-1.45)	0.002	0.0	0.451

PBL: Problem-based learning, SDM: Standardised mean difference, RR: Relative risk, CI: Confidence interval, P: P value of statistical test for effect of each variable, PHet: P value of heterogeneity statistical test.

The possible reasons behind PBL's effectiveness include its focus on students rather than the faculty, and because PBL stimulates students' learning interest and expands academic thinking.[39]

The current data showed high level of heterogeneity among the studies analysed. This may be because the understanding and implementation process of PBL method among the teachers in China may be very different. Differences in teaching level and educational quality exist among different medical schools, and students may have also different knowledge



A: The effect of PBL on test scores compared to LBL, B: Effect on learning interest, C: Effect on self-learning ability, D: Effect on collaboration skill, PBL: Problem-based learning, LBL: Lecture-based learning

Figure-3: Sensitivity analysis on the effect evaluation of PBL teaching compared to LBL in epidemiology and health statistics.

backgrounds. In addition, there may be other factors contributing to heterogeneity among studies. To date, there are no uniform criteria for assessing PBL effectiveness in terms of learning knowledge and related skills. Some variables are needed to contract and decide the heterogeneity factor in future.

There are some limitations in the present systematic review. First, the methodological quality of the included articles was not very high. Although two researchers independently conducted literature search, selection bias and performance bias persisted across the studies. Also, the overall sample size of the included studies was relatively small which may affect the test efficiency of overall statistical analysis. Therefore, high-quality studies with large sample size needs to be conducted to confirm the current findings.

Conclusion

PBL was found to improve test scores, learning interest, autonomous learning ability and collaboration skills in Epidemiology and Health Statistics courses in China. However, the local education system, cultural background, quality and ability of teachers and students, and available teaching resources should also be considered before the implementation of PBL teaching model.

Acknowledgements: We are grateful to the Guangxi Higher Education Teaching Reform Project for financial assistance.

Disclaimer: None.

Conflict of Interest: None.

Source of Funding: The Guangxi Higher Education Teaching Reform Project, China [grant numbers 2020JGA266] and Guilin Medical College Graduate Education and Teaching Reform Project [grant numbers 31103022037].

References

1. Wang D, Zhou J, Wu Q, Sheng G, Li X, Lu H, et al. Enhancement of Medical Students' Performance and Motivation in Pathophysiology Courses: Shifting From Traditional Instruction to Blended Learning. Front Public Health. 2022; 9:813577. doi: 10.3389/fpubh.2021.813577.
2. Chen M, Ni C, Hu Y, Wang M, Liu L, Ji X, et al. Meta-analysis on the effectiveness of team-based learning on medical education in China. BMC Med Educ. 2018; 18:77. doi: 10.1186/s12909-018-1179-1.
3. Jing F, Li Y, Ding Y, Gao Q, Fan C. The Influence of Four Different Teaching Methods in Medical Statistics: a Network Meta-Analysis. Zhejiang Med Educ. 2018; 17:4-7.
4. Trullàs JC, Blay C, Sarri E, Pujol R. Effectiveness of problem-based learning methodology in undergraduate medical education: a scoping review. BMC Med Educ. 2022; 22:104. doi: 10.1186/s12909-022-03154-8.
5. Zhang S, Xu J, Wang H, Zhang D, Zhang Q, Zou L. Effects of problem-based learning in Chinese radiology education: A systematic review and meta-analysis. Medicine (Baltimore). 2018; 97:e0069. doi: 10.1097/MD.0000000000010069.
6. Colliver JA. Effectiveness of problem-based learning curricula: research and theory. Acad Med. 2000; 75:259-66. doi: 10.1097/00001888-200003000-00017.
7. Dochy F, Segersb M, Van den Bosscheb P, Gijbels D. Effects of problem-based learning: a meta-analysis.Learn Instr. 2003; 13:533-68. doi.org/10.1016/S0959-4752(02)00025-7
8. KhoshnevisasI P, Sadeghzadeh M, Mazloomzadeh S, Feshareki RH, Ahmadiafshar A. Comparison of Problem-based Learning With Lecture-based Learning. Iran Red Crescent Med J. 2014; 16:e5186. doi: 10.5812/ircmj.5186.
9. Gan L, Deng X, Chen H, Liu C, Yang, M, Lin C, et al. Comparison of problem-based and team-based learning on Chinese basic medical education for clinical medicine: a pilot study. MBC Med Educa. 2020; 1-19. DOI: 10.21203/rs.3.rs-23853/v1
10. Moher D, Shamseer L, Clarke M, Ghersi D, Liberati A, Petticrew M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. Syst Rev. 2015; 4:1. doi: 10.1186/2046-4053-4-1.
11. Higgins JPT, Green S. Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0. London: The Cochrane Collaboration, 2011.
12. Begg CB, Mazumdar M. Operating characteristics of a rank correlation test for publication bias. Biometrics. 1994; 50:1088-101.
13. Wang P, Xie W, Song C. Application effect of PBL teaching mode combined with case teaching method in clinical epidemiology teaching of Postgraduates. Chin J Infec Contr.2017; 32:1188-90.
14. Sun N, Zhang RQ, Liu QL. The discussion of PBL teaching mode on epidemiological WeChat platform. Stat Mana. 2016; 10:181-2.
15. Tao N, Tang H, Yong XT, An H. Research on the application of participatory teaching in the practice teaching of epidemiology. Cont Med Educ. 2016; 30:25-7.
16. Zhao X, Mao S, Zhang F. The practice of case-oriented PBL in the teaching of clinical epidemiology. Chin Higher Med Edu.2015; 2015:98-9.
17. Liu W, Zhang P, Zhang X, Gao X, Li T, Yang L. The application of PBL and CBL in epidemiology teaching. Edu Forum.2015; 2015:162-4.
18. Yin ZH, Cui ZG, Hu W. The application of the problem-based teaching model in the teaching of epidemiology practice. J Pre Med Info.2014; 30:84-6.
19. Song L, Jiang S, Tan S, Shi W, Lv Y, Yu H. Research on the application of the teaching mode of the problem- learning method in epidemiology teaching. Chin J Dis Control Prev.2014; 18:568-70.
20. Yang J, Yuan J, Zhang J. The application of PBL teaching method in epidemiology teaching effect assessment. Med Res Edu.2013; 30:97-100.
21. Lu Y, He S, Tian T, Shen Y, Zhuang X. The application effect of PBL teaching method in epidemiology course evaluation. Med J Commu.2013; 27: 316-8.
22. Tian J, Liu A, Shen X, Yang K. PBL teaching method in the application of evidence-based medicine teaching effect assessment. Chin J Evidence-based Med.2011; 11:39-43.
23. Lu Z, Yan J, Zhang D, Sun W, Zhang L, Wen J, et al. PBL teaching mode in the teaching of graduate students of clinical epidemiology. Chin J Modern Med. 2011; 21:1126-8.
24. Zhang M, Sun XH, Wu WP, Cao Y. Assessment of the effect of traditional teaching method and the PBL teaching mode in medical statistics teaching. Chin Cont Med Edu. 2016; 8:18-9.
25. Pan S, Zhang R, Lu Z, Wu X, Sun W. Research on PBL teaching practice of Health Statistics. Chin Rural Heal Ser Admin. 2016; 36:311-3.

26. Wang J, Yan G, Sun C, Xu X. Evaluation the traditional and PBL teaching method of medical statistics in colleges of TCM. Chin Med Modern Dis Edu. 2015; 13:82-3.
27. Wang S, Wang X, Gao Y, Du M. Evaluation of PBL teaching mode in undergraduate teaching of Health Statistics. Acta Academ Med Neimongol. 2014; 36:375-78.
28. Li G, Zhang L. PBL in the teaching of medical statistics. J Educ Institute Jilin Prov. 2013; 29:53-5.
29. Sun R, Wang J, Sun F. Evaluation of the effect of PBL teaching mode in medical statistics teaching. Edu Chin After School.2010; 2010:95-54.
30. Zhang Y, Wang W, Liu L, Wu Y, Yi D. PBL teaching reform of medical statistics. Expl Med Edu.2010; 9:1697-9.
31. Xu L, Cai X. Evaluation on effect of introducing problem-based learning in medical statistics teaching. Chin Nur Res. 2010; 24:2891-2.
32. Zhang Y, Guo C, Huang J. The application of PBL in the teaching of health statistics in Higher Vocational Education. J Anhui Heal Voc Tech Coll. 2009; 8:89-90.
33. Liu CX, Ouyang WW, Wang XW, Chen D, Jiang ZL. Comparing hybrid problem-based and lecture learning (PBL + LBL) with LBL pedagogy on clinical curriculum learning for medical students in China: a meta-analysis of randomized controlled trials. Medicine (Baltimore). 2020; 99:e19687. doi: 10.1097/MD.0000000000019687.
34. Frambach JM, Driessen EW, Chan LC, van der Vleuten CP. Rethinking the globalisation of problem-based learning: how culture challenges self-directed learning. Med Educ. 2012; 46:738-47. doi: 10.1111/j.1365-2923.2012.04290.x.
35. Liu L, Du X, Zhang Z, Zhou J. Effect of problem-based learning in pharmacology education: A meta-analysis. Stud Educ Eval. 2019; 60:43-58. doi:10.1016/j.stueduc.2018.11.004
36. Ma Y, Lu X. The effectiveness of problem-based learning in pediatric medical education in China: A meta-analysis of randomized controlled trials. Medicine (Baltimore). 2019; 98:e14052. doi: 10.1097/MD.0000000000014052.
37. Bi S, Liu R, Li J, Gu J. The effectiveness of problem-based learning in gynecology and obstetrics education in China: A meta-analysis of randomized controlled trials. Medicine (Baltimore). 2021; 100:e24660. doi: 10.1097/MD.0000000000024660.
38. Sayyah M, Shirbandi K, Saki-Malehi A, Rahim F. Use of a problem-based learning teaching model for undergraduate medical and nursing education: a systematic review and meta-analysis. Adv Med Educ Pract.2017; 8:691-700. doi: 10.2147/AMEP.S143694.
39. Ren X, Yin J, Wang B, Roy Schwarz M. A descriptive analysis of medical education in China. Med Teach. 2008; 30: 667-72. doi: 10.1080/01421590802155100.