

Application of Blended Learning in Basic Medical Courses for Medical Students: A Systematic Review and Meta-Analysis

INPLASY2025100109
doi: 10.37766/inplasy2025.10.0109
Received: 27 October 2025
Published: 27 October 2025

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ADMINISTRATIVE INFORMATION

Support - This work was supported by Shiyan City Scientific Research Fund(24Y030,24Y059),the Shiyan City Taihe Hospital Fund (No.2019JJXM021, No.2020JJXM052, No.2022JJXM082, No.2024JJXM029) and Hubei University of Medicine Graduate Education and Teaching Research Approved Project (YJ2025066),Undergraduate Innovation and Entrepreneurship Training Program of Hubei University of Medicine (X202510929073).

Review Stage at time of this submission - Completed but not published.

Conflicts of interest - None declared.

INPLASY registration number: INPLASY2025100109

Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 27 October 2025 and was last updated on 27 October 2025.

INTRODUCTION

Review question / Objective (1) Population(P): Medical students.(2) Intervention (I): Experimental group employing a blended learning (online and offline) teaching model.(3) Comparison (C): Control group using traditional offline teaching methods.(4) Outcome (O): Teaching satisfaction and academic performance.(5) Study design (S): Randomized controlled trials assessing the impact of blended learning on basic medical education.

Rationale Prior studies exhibit differences in sample sizes, teaching interventions, and other factors, leading to varying results and making it difficult to draw a unified conclusion. Therefore, it is essential to apply meta-analysis to

systematically integrate and quantitatively assess these dispersed studies, providing a comprehensive and objective evaluation of the impact of blended learning on medical students' education. This will offer scientific and reliable decision-making support for medical educators in selecting and optimizing teaching models, ultimately enhancing the quality of medical education and producing professionals better equipped to meet the demands of modern healthcare. The aim of this meta-analysis is to evaluate the intervention effects of blended learning on medical students' satisfaction and academic performance in basic medical courses.

Condition being studied The blended learning model effectively integrates the strengths of both offline and online teaching. Through online

learning, students can independently study foundational knowledge, familiarize themselves with course content in advance, and identify areas of difficulty and questions for further clarification. In contrast, offline sessions focus on practical skills, group discussions, case analysis, and targeted instructor guidance, enabling students to translate theoretical knowledge into practical application. Additionally, these in-person activities promote interaction and collaboration among students, fostering teamwork and clinical thinking skills. In medical education, this blended approach can be applied across various disciplines, such as anatomy and physiology in basic medical courses. Online resources, such as 3D models and animations, provide students with a clearer understanding of human anatomy and physiological mechanisms, while offline sessions involve hands-on experiments and cadaver dissections for deeper learning.

METHODS

Search strategy PubMed: ("medical student"[Text Word] OR "Students, Medical"[Mesh])AND("blended learning"[Text word] OR "hybrid learning"[Text Word] OR "blended course"[Text Word]) AND ("basic medical science"[Text Word] OR "anatomy"[Text Word] OR "Anatomy"[Mesh] OR "physiology"[Text Word] OR "Physiology"[Mesh] OR "biochemistry"[Text Word] OR "Biochemistry"[Mesh] OR "pharmacology"[Text Word] OR "Pharmacology"[Mesh] OR "pathology"[Text Word] OR "Pathology"[Mesh] OR "microbiology"[Text Word] OR "Microbiology"[Mesh]) AND ("student satisfaction"[Text Word] OR "learner satisfaction"[Text Word] OR "Consumer Behavior"[Mesh] OR "academic achievement"[Text Word] OR "academic performance"[Text Word] OR "Academic Success"[Mesh] OR "course grade"[Text Word] OR "exam score"[Text Word] OR "test score"[Text Word] OR "Educational Measurement"[Mesh])
Web of Science:TS=("blended learning" OR "hybrid learning" OR "blended course*" OR "mixed-mode learning")) AND
TS=("medical students" OR "medical educators") AND
TS=("basic medical science" OR "anatomy" OR "physiology" OR "biochemistry" OR "pharmacology" OR "pathology" OR "microbiology" OR "cell biology" OR "gross anatomy" OR "histology" OR "embryology" OR "immunology" OR "foundation medic")) AND
TS=("satisfaction" OR "teaching satisfaction" OR "student satisfaction" OR "exam scores" OR

"knowledge acquisition" OR "theoretical knowledge" OR "learning outcomes")
Cochrane Library: ("medical students") AND ("blended learning" OR "hybrid learning" OR "blended course")AND("basic medical science" OR "basic science" OR "anatomy" OR "physiology OR "biochemistry" OR "pharmacology" OR "pathology" OR "microbiology" OR "cell biology" OR "gross anatomy" OR histology" OR embryology" OR immunology") AND("lecture-based learning" OR "traditional teaching" OR "conventional teaching") AND("satisfaction" OR "knowledge")
Education Resources Information Center (ERIC): ("blended learning" OR "hybrid learning" OR "blended course")) AND
("medical student" OR "medical education" OR "medical school")) AND
("basic medical science" OR anatomy OR physiology OR biochemistry OR pharmacology OR pathology OR microbiology OR "cell biology" OR "gross anatomy" OR histology OR embryology OR immunology)) AND
("academic achievement" OR "student achievement" OR "course grade" OR "exam score" OR "test performance" OR "learning outcome") OR ("student satisfaction" OR "learner satisfaction" OR "student perception" OR "student attitude"))
China National Knowledge Infrastructure (CNKI):
线上线下混合式 + 线上线下混合式教学 + 线上线下混合式课程+基础医学 + 基础医学课程 + 基础医学教育 + 基础医学教学 + 基础医学实验教学+成绩 + 成绩评定 + 成绩考核 + 学习成绩 + 考试成绩 + 满意度 + 满意度评价+医学生 + "医学院校"
Wanfang: ("线上线下混合式教学" OR "线上线下混合式课程" OR "线上线下混合式混合式学习") AND
(("医学生" OR "医学本科生" OR "临床医学生" OR "护理学生" OR "医学院校") OR ("医学教育" OR "本科生")) AND
(("基础医学" OR "基础医学课程" OR "基础医学教育" OR "基础医学教学" OR "基础医学实验教学")) AND
(("教学满意度" OR "学习满意度" OR "满意度" OR "课程成绩" OR "考试成绩" OR "考核成绩" OR "学业表现" OR "总分") OR ("教学效果" OR "学习成果" OR "学习效能"))
VIP : ("医学生" OR "临床医学生" OR "护理学生" OR "医学院校")

AND("混合式教学" OR "混合式学习" OR "线上线下教学" OR "线上线下融合")

AND("基础医学" OR "系统解剖学" OR "组织学" OR "胚胎学" OR "生理学" OR "病理生理学" OR "药理学" OR "病理学" OR "生物化学" OR "分子生物学" OR "免疫学" OR "微生物学" OR "人体寄生虫学")

AND("教学满意度" OR "学习满意度" OR "满意度调查" OR "课程成绩" OR "考试成绩" OR "考核成绩" OR "学业表现").

Participant or population Medical students.

Intervention Employing a blended learning (online and offline) teaching model.

Comparator Using traditional offline teaching methods.

Study designs to be included Randomized Controlled Trials.

Eligibility criteria Inclusion criteria:

(1) Population(P): Medical students.(2) Intervention (I): Experimental group employing a blended learning (online and offline) teaching model.(3) Comparison (C): Control group using traditional offline teaching methods.(4) Outcome (O): Teaching satisfaction and academic performance.(5) Time (T): One academic semester.(6) Study design (S): Randomized controlled trials assessing the impact of blended learning on basic medical education.

Exclusion criteria:

(1) Studies unrelated to blended learning (online and offline) teaching methods.(2) Non-comparative studies.(3) Research that do not report key outcomes, including academic performance and teaching satisfaction .(4)Research from which data cannot be extracted or transformed.(5) Research for which full-text articles are not accessible.

Information sources PubMed, Web of Science, Cochrane Library, Education Resources Information Center (ERIC), China National Knowledge Infrastructure (CNKI), Wanfang Data Knowledge Service Platform, and VIP Chinese Science and Technology Journals Database.

Main outcome(s) Teaching satisfaction and academic performance.

Quality assessment / Risk of bias analysis To evaluate the methodological quality of the studies that were included, the Cochrane Risk of Bias 2.0 (ROB 2.0) tool was employed. This assessment focused on six core domains: the overall risk of bias, how reported outcomes were selected, the

way outcomes were measured, missing data related to outcomes, bias in the delivery of intended interventions, and the process of randomization. For each of these domains, the risk of bias was sorted into one of three categories: low risk, some concerns, or high risk. Since the evaluation process inherently carries a degree of subjectivity, steps were taken to reduce this as much as possible: two reviewers carried out the quality assessment independently, and each provided detailed explanations to support their judgments. If there were conflicting views between the two reviewers, the problem was addressed either through in-depth discussion between them or by seeking arbitration from a third party. This approach ensured that the final assessment results were consistent and objective. After completing the bias risk assessment, the overall certainty of the evidence was rated using the GRADE evidence grading system. Under this system, evidence certainty is divided into four levels: high, moderate, low, and very low.

Strategy of data synthesis Data analysis was conducted with the use of RevMan 5.4 and Stata 15.1 software tools. In educational intervention research, it is common for included studies to have unavoidable methodological heterogeneity; thus, a random-effects model (RE) was adopted to synthesize the collected data. When dealing with continuous outcome variables—such as indicators of academic performance—the research team calculated standardized mean differences (SMD). For binary outcomes, like levels of teaching satisfaction, odds ratios (OR) were computed instead. Besides this, the 95% confidence intervals (CIs) corresponding to each effect size were also calculated. To evaluate how stable the study findings were, a leave-one-out (LOO) sensitivity analysis was carried out. In this analysis, each individual study was excluded one after another, and the data analysis process was repeated each time the exclusion occurred. Subgroup analyses were also performed to compare result variations across different educational levels and subject fields. These subgroup analyses placed special emphasis on differences in academic performance seen across various stages of medical education and different course types. Additionally, the analyses involved systematically investigating potential sources of heterogeneity, which helped to improve the interpretability of the overall results. Finally, visual analysis of funnel plots was conducted, and Egger's regression test was implemented to identify any small study effects.

Subgroup analysis Subgroup analysis based on education level revealed the following findings: The

subgroup of diploma students included 8 studies (SMD = 1.33, 95% CI = 0.77–1.89, $p < 0.001$), with significant heterogeneity (heterogeneity test $p < 0.001$, $I^2 = 96\%$). The undergraduate subgroup included 18 studies (SMD = 1.29, 95% CI = 0.82–1.75, $p < 0.001$), also showing significant heterogeneity (heterogeneity test $p < 0.001$, $I^2 = 97\%$).

Subgroup analysis by subject revealed significant findings in several areas. The Physiology subgroup, which included 8 studies, showed a moderate effect (SMD = 0.68, 95% CI = 0.36–1.00, $p < 0.001$) with significant heterogeneity (heterogeneity test $p < 0.001$, $I^2 = 86\%$). The Pathology subgroup, with 3 studies, demonstrated a larger effect (SMD = 0.93, 95% CI = 0.02–1.84, $p = 0.05$) but also exhibited significant heterogeneity (heterogeneity test $p < 0.001$, $I^2 = 96\%$). The Anatomy subgroup, consisting of 4 studies, showed a large effect (SMD = 2.79, 95% CI = 0.46–5.12, $p = 0.02$) with substantial heterogeneity (heterogeneity test $p < 0.001$, $I^2 = 99\%$). In the Histology and Embryology subgroup, which also included 4 studies, the effect was moderate (SMD = 1.53, 95% CI = 0.03–3.04, $p = 0.04$), with significant heterogeneity (heterogeneity test $p < 0.001$, $I^2 = 98\%$). In contrast, the Oral Pathology subgroup, based on just 1 study, showed no significant effect (SMD = 0.81, 95% CI = -0.12–0.48, $p = 0.24$).

Sensitivity analysis A systematic LOO sensitivity analysis was carried out, which involved excluding each study one after another in sequence. As shown in Figure 5, the analysis results reveal that the combined effect size related to academic performance stayed consistently within its initial 95% confidence interval (CI)—a finding that points to the relative robustness of the study's conclusions.

Country(ies) involved China.

Keywords Blended learning; Basic medical courses; Meta-analysis; Academic performance; Teaching satisfaction.

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