International Education Forum, 2025, Volume 3, Issue 9
http://ojs.bbwpublisher.com/index.php/IEF
Online ISSN: 2981-8605
Print ISSN 3083-4902

Visualization Analysis of Research Frontiers and Hotspots of CBL in Medical Education in China Based on CiteSpace

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Abstract: *Objective:* This study aims to carry out a visualization analysis of the research literature on Case-Based Learning (CBL) in the field of medical education in China, thereby providing a reference for medical educators and researchers. *Methods:* Literature related to CBL teaching methods was retrieved from databases such as CNKI and visualized using CiteSpace software. *Results:* CBL research in China demonstrates phased characteristics. The research hotspots encompass application, innovation in teaching models, and clinical practice. The research has evolved from the establishment of basic methods (2006–2012) to the evaluation of effects and the application of technology (2013–2018), and further to curriculum integration and professional development (2019–2024). *Conclusion:* CBL research has made progress; however, it still faces issues such as insufficient theoretical exploration. Future research should focus on strengthening theoretical construction, delving deeper into teaching principles, adopting rigorous research designs and multi-dimensional assessment methods, and exploring the integration of information technology to promote the extensive application and in-depth development of CBL teaching methods.

Keywords: CBL; CiteSpace; Bibliometrics

Online publication: October 16, 2025

1. Introduction

Case-Based Learning (CBL), as an effective teaching method, has been widely applied and researched in the field of medical education [1]. By integrating theoretical knowledge with practical cases, CBL can enhance students' clinical thinking abilities and practical skills, while also boosting their interest and engagement in learning [2]. In recent years, with the continuous advancement of medical education reform, the application of CBL in medical education in China has become increasingly widespread, making it one of the important research hotspots in medical education. Understanding the research frontiers and hotspots of CBL in the

field of medical education in China can help educators and researchers better grasp the development trends of the discipline, optimize teaching methods and content, and improve the quality of medical education. A CiteSpace visualization analysis of medical education in China can clearly illustrate the research hotspots and frontier trends of CBL in this field, identify gaps and deficiencies in research, and provide directions and ideas for future studies.

2. Materials and methods

2.1. Literature retrieval strategy

The databases of CNKI, Wanfang, and VIP were searched using the keywords "CBL", "Case-Based Learning", or "case-based teaching method", along with "medicine", from the inception of the databases to December 2024. The search was conducted on January 3, 2025.

2.2. Inclusion and exclusion criteria

Inclusion criteria encompassed studies related to the application of CBL in medical education, including its application, effectiveness evaluation, instructional design, and reform. The literature types included formally published works, such as journal articles. Exclusion criteria comprised literature unrelated to this study, such as CBL research in non-medical education fields, dissertations, conference papers, newspapers, and books.

2.3. Literature analysis method

The literature was imported into the NoteExpress software for management. Basic information (such as publication year, research institution, source, research type, funding support, and keywords) and content information were extracted. After exporting the data as a RefWorks format file, it was imported into CiteSpace 6.1.R5 for visualization analysis, generating various visual co-occurrence maps. Research hotspots and development trends were understood through node sizes and connections.

3. Results

3.1. Analysis of publication volume

The number of academic papers serves as a key indicator for measuring the development of a field. From 2006 to 2013, the volume of publications in the CBL field was low, with only 66 papers published in 2013, marking the stage of concept introduction and preliminary exploration. From 2014 to 2020, the field entered a period of rapid growth, reaching 315 papers in 2020, indicating rapid development driven by advancements in educational technology, increased demand for medical education reform, and recognition of the effectiveness of CBL in enhancing clinical thinking skills. From 2021 to 2024, the field entered a mature and adjustment phase, with a peak of 372 papers published in 2021 and a total of 2,152 papers. Despite a decline in 2022–2023, the overall publication volume continued to grow, indicating that the CBL field has entered a mature stage where researchers are integrating and deepening their findings. **Figure 1** illustrates the rise and maturation of CBL in Chinese medical education research.

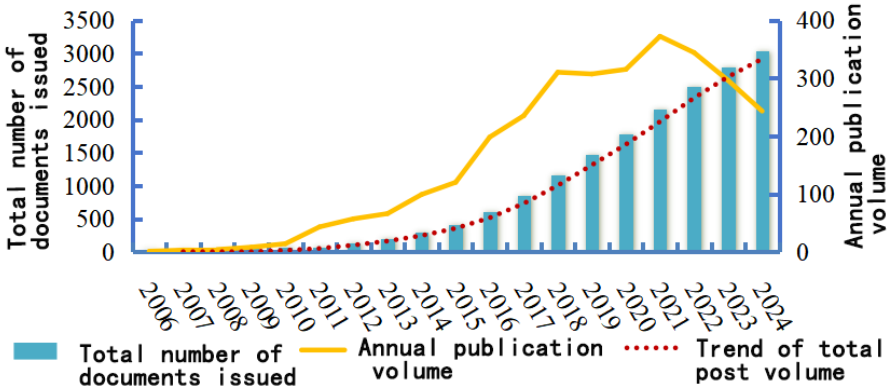

Figure 1. Trend chart of publication volume

3.2. Keyword co-occurrence analysis

Keyword analysis reveals that CBL teaching methods and case-based teaching methods are focal points in medical education research, mentioned 405 and 275 times, respectively (**Figure 2**). Teaching models and methods, as core themes, appeared 231 and 218 times, respectively, indicating researchers' focus on innovation and application. Initially, research focused on CBL teaching, teaching reform, and medical education, then shifted to clinical teaching (264 times), clinical internships (98 times), and clinical clerkships (88 times), emphasizing the application of CBL in clinical practice. The mention of teaching effectiveness and standardized training indicates researchers' attention to the efficacy and standardization of CBL. Research on emerging teaching models, such as flipped classrooms, PBL teaching, and applications in medical imaging, reflects innovation and expansion in the CBL field.

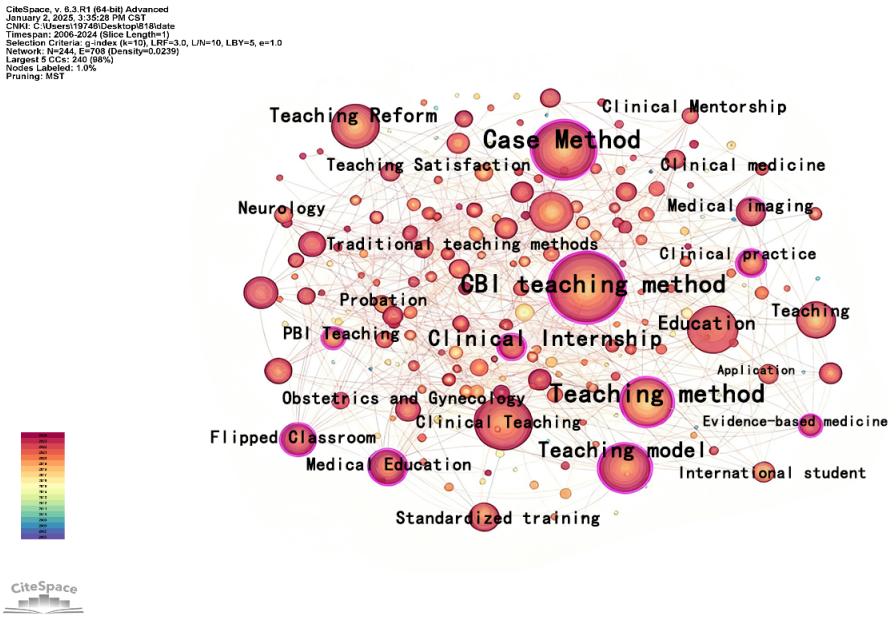

Figure 2. Keyword co-occurrence map

3.3. Keyword clustering analysis

Keyword clustering analysis reveals the knowledge structure and dynamic evolution of the field. **Figure 3** displays several important clusters: #0 focuses on the application of teaching methods; #1 explores the impact of teaching models; #2 involves content of teaching reform; #3 focuses on issues in teaching practice; #4 studies the application of information technology; #5 focuses on internships and training for medical students; #6 involves feedback on educational quality; #7 explores cross-institutional collaboration models.

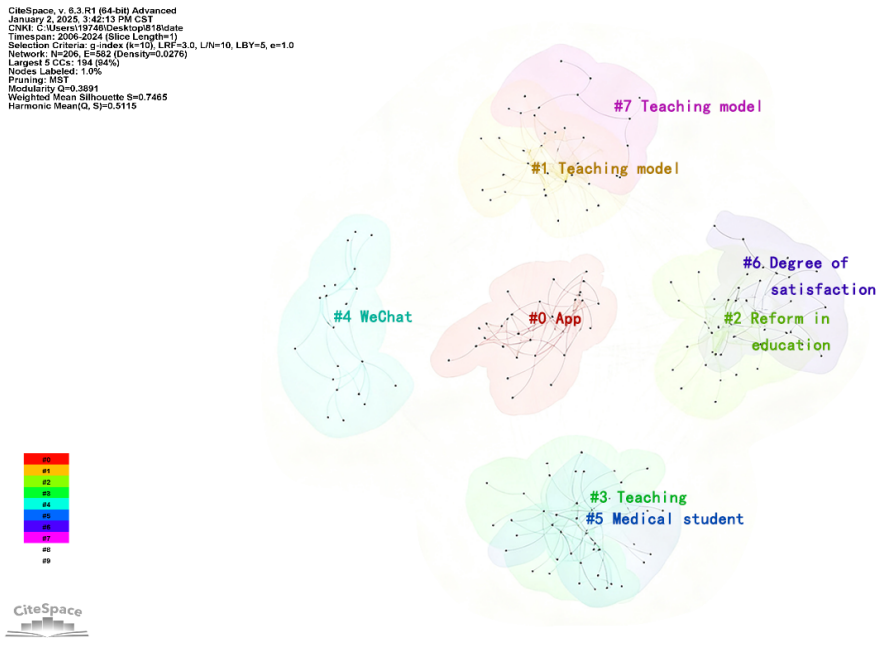

Figure 3. Keyword clustering analysis

3.4. Analysis of research frontiers

Research frontiers uncover innovation points and future trends. The timeline view (**Figure 4**) illustrates clustering relationships and the historical progression of literature, while the keyword timezone view (**Figure 5**) displays the evolution of keywords over time, revealing shifts in research hotspots and domain dynamics, thereby fostering interdisciplinary innovation. The study of CBL can be divided into three stages: from 2006 to 2012, the focus was on establishing and improving foundational teaching methodologies, incorporating the concept of evidence-based medicine; from 2013 to 2018, the emphasis shifted to evaluating teaching effectiveness, with attention given to new teaching methods and the application of information technology; from 2019 to 2024, the focus has turned to curriculum integration and professional development, emphasizing student-centered evaluation concepts and the application of the holistic health concept, reflecting the continuous exploration in medical education to enhance quality, adapt to technological advancements, and meet professional demands.

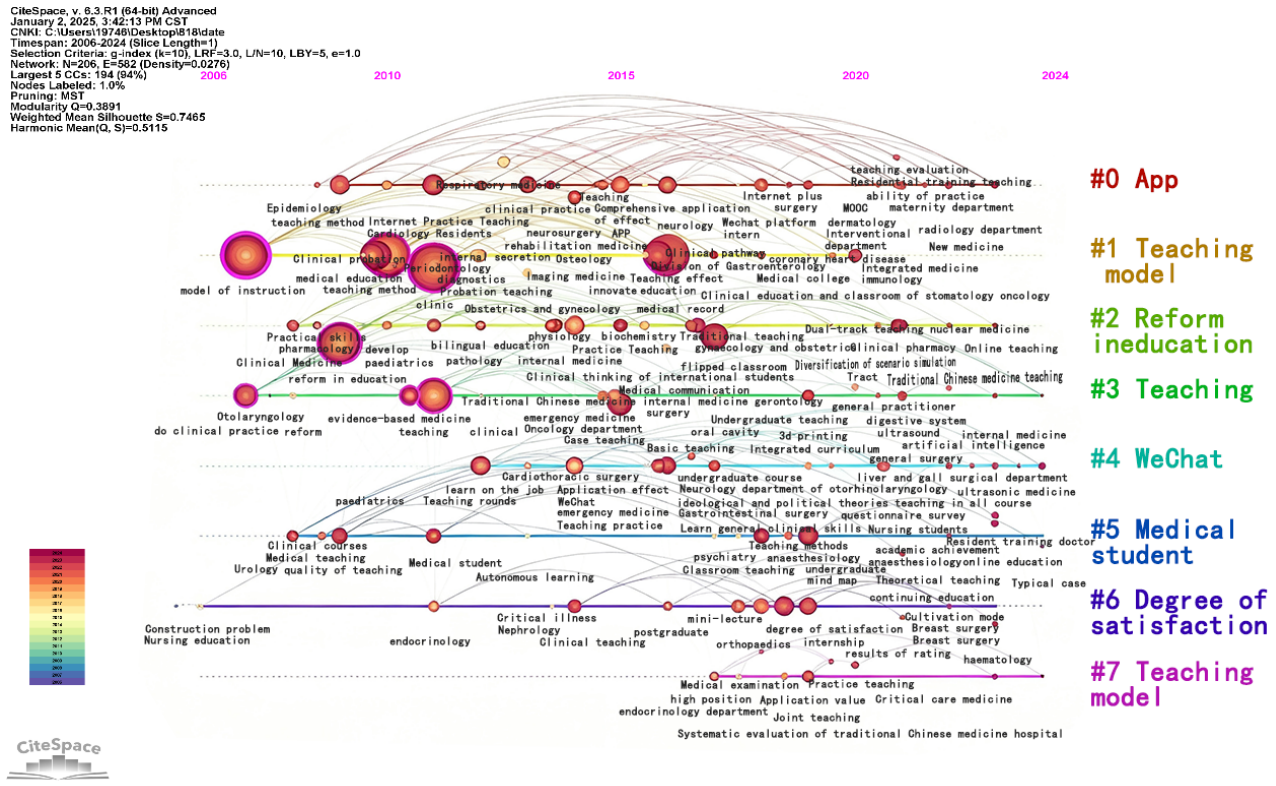

Figure 4. Keyword timeline view

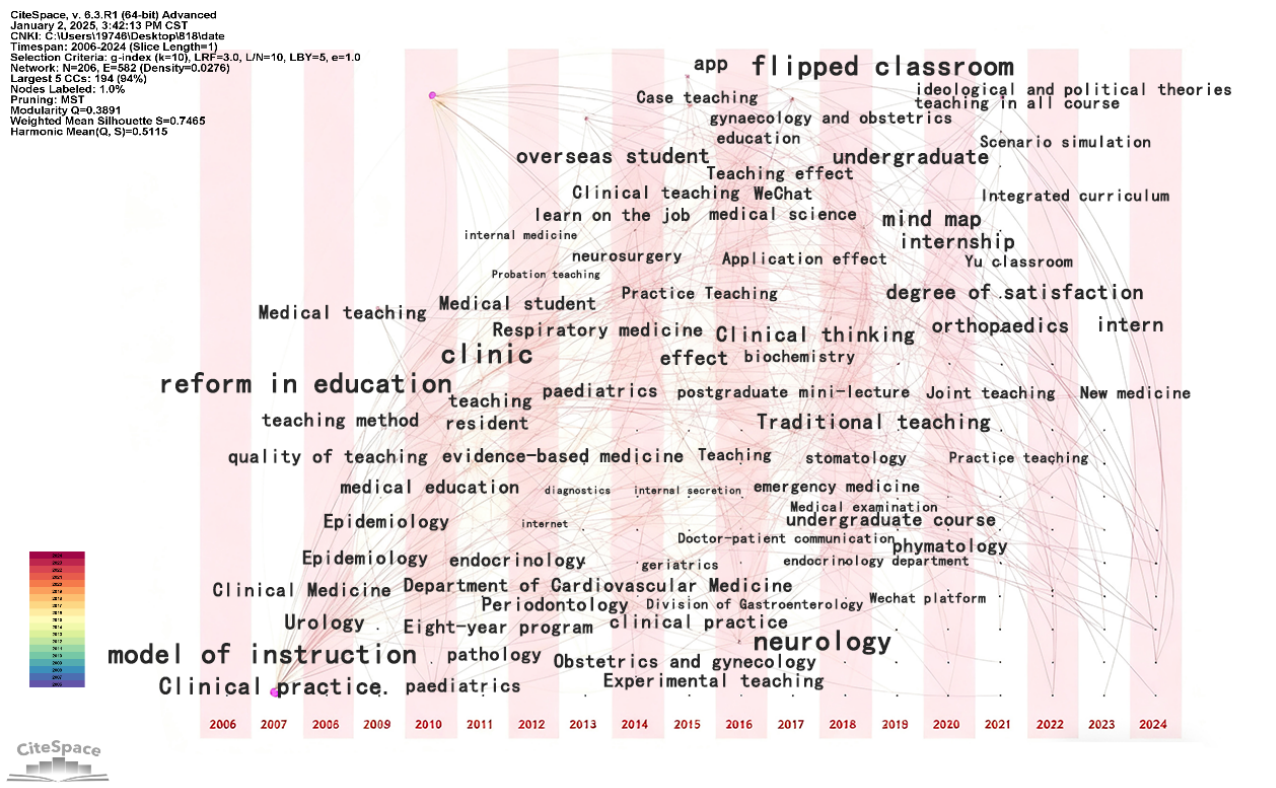

Figure 5. Keyword timezone view

3.5. Mountain chart analysis

The CiteSpace keyword mountain chart visually represents the research intensity and trends of different keywords within the CBL field across various time periods. **Figure 6** displays multiple clusters, such as "#0 Application", which peaked in 2021, reflecting the application and effectiveness of CBL in medical education; "#1 Teaching Model" and "#2 Teaching Reform", which peaked in 2011 and 2018, respectively, indicating exploration and evaluation of teaching methods; "#4 WeChat", which saw peaks in 2016 and 2021, demonstrating its application research in the educational field; "#6 Satisfaction", which peaked in 2021 and 2024, focusing on student satisfaction and educational outcomes of CBL programs; and "#7 Joint Teaching", which gained attention in 2016 and 2021, reflecting the importance of cross-institutional collaborative teaching models.

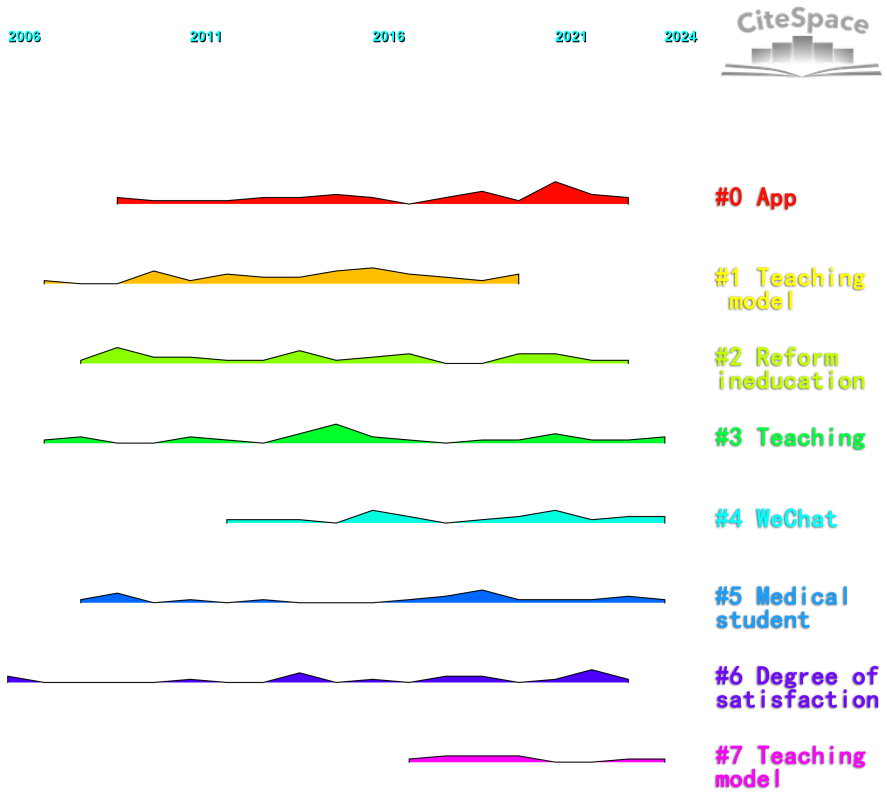

Figure 6. Keyword mountain chart

4. Discussion

This study systematically reviewed the current research landscape of Case-Based Learning (CBL) in medical education in China using CiteSpace, a visualization analysis tool. The study unveiled the application hotspots, development trends, and frontiers of CBL, providing educators and researchers with a clear research trajectory and future directions. Through keyword co-occurrence, cluster analysis, and timeline analysis, the development trajectory of CBL in Chinese medical education was summarized, highlighting research gaps and potential innovation points. This provides theoretical support and practical guidance for optimizing teaching methods and enhancing the quality of medical education.

The study found that research on CBL in Chinese medical education has undergone three distinct phases: the concept introduction and initial exploration phase from 2006 to 2012, the rapid development and teaching effectiveness evaluation phase from 2013 to 2018, and the curriculum integration and professional development phase from 2019 to 2024. Early research focused on establishing and refining the foundational aspects of the CBL teaching methodology, then shifted towards evaluating teaching effectiveness and exploring novel teaching models, ultimately converging on higher-level educational objectives such as curriculum integration, ideological and political education in courses, and professional development [2–3]. This phased characteristic reflects the gradual advancement of medical education reform in China, aligning with both domestic and international trends in medical education reform and demonstrating the flexibility and effectiveness of CBL in adapting to changes in medical education [2, 4].

Keyword co-occurrence and cluster analyses revealed that research hotspots in CBL are concentrated in areas such as teaching models, teaching effectiveness, clinical teaching, flipped classrooms, and ideological and political education in courses [5]. These hotspots reflect the core application directions of CBL in medical education, particularly its significance in clinical practice teaching. The emergence of emerging keywords such as "ideological and political education in courses", "new medical discipline", and "eight-year medical program" indicates that CBL research is expanding into broader educational philosophies and professional development areas. The timeline view and keyword time zone map revealed the dynamic evolution of CBL research, progressing from early exploration of basic teaching methods to mid-term evaluation of teaching effectiveness, and then to recent curriculum integration and professional development, reflecting the increasing depth and breadth of CBL research.

The integration of Case-Based Learning (CBL) with other teaching methods (such as flipped classrooms and Problem-Based Learning (PBL)), as well as the application of information technology (e.g., WeChat) in teaching, has emerged in CBL research. These innovative approaches have not only enriched the CBL teaching model but also enhanced the interactivity and flexibility of teaching [6]. For instance, the combination of flipped classrooms and CBL provides students with a more autonomous learning environment, while the application of information technologies like WeChat offers a more convenient platform for communication and resource sharing in teaching [7]. Furthermore, the exploration of cross-institutional collaborative teaching models has also provided new insights for the promotion and application of the CBL teaching method.

Internationally, CBL, as a mature teaching method, has been widely adopted in medical education, forming a relatively comprehensive theoretical framework and practical model. CBL research in China started relatively late but has developed rapidly, making significant progress in recent years in areas such as teaching effectiveness evaluation, curriculum integration, and professional development, gradually aligning with international research [2]. In international studies, the application of CBL is more extensive, covering multiple disciplines, whereas in China, research primarily focuses on medical education, particularly in clinical teaching, clinical internships, and clinical clerkships, reflecting the specific needs of medical education reform in China. Compared with domestic related research, this study, through CiteSpace visual analysis, not only summarizes the application hotspots of CBL but also reveals research frontiers and potential innovative points.

The research data is based on Chinese literature from databases such as CNKI, Wanfang, and VIP, excluding international achievements, which may affect the comprehensiveness and international perspective of the study. While the CiteSpace analysis tool visually displays research hotspots and trends, it lacks depth

in analysis. For example, keyword co-occurrence analysis only reveals superficial associations between topics without delving into the underlying logic and theoretical foundations of the content. The discussion of research limitations and potential issues is not comprehensive enough, and specific improvement suggestions are not proposed.

Future research should deepen the theoretical foundation of the CBL teaching method and explore its role and influencing factors in medical education [8]. By integrating multidisciplinary theories, the impact of CBL on student learning should be analyzed to optimize teaching design. Currently, CBL is primarily applied in clinical teaching, but in the future, it should be extended to basic medicine, preventive medicine, and medical humanities courses to promote comprehensive development. Research should be conducted on the application of CBL in the interdisciplinary fields of medicine and other disciplines to cultivate versatile talents. With the advancement of educational technology, it is essential to enhance the integration of CBL with other teaching methods and technologies, such as flipped classrooms, Problem-Based Learning (PBL), virtual reality, and artificial intelligence, to improve interactivity and personalization levels [9]. Research on the application of CBL in online and blended learning should be carried out to support the digital transformation of medical education [1]. Strengthening cross-institutional collaboration, promoting resource sharing, and enhancing educational quality are also crucial. Multi-center CBL teaching experimental studies should be conducted to compare the differences in CBL teaching effectiveness across different institutions and optimize teaching models [10]. Drawing on international experience, the internationalization of medical education should be promoted. Attention should be paid to constructing a CBL teaching evaluation system, exploring evaluation indicators and methods, and comprehensively assessing teaching effectiveness [11]. Research on teaching quality assurance mechanisms should be conducted to ensure high-quality CBL teaching through measures such as teaching supervision, teacher training, and student feedback.

Funding

Scientific Research Fund Project of China Three Gorges University (Project Number: 2022kj008); Scientific Research Special Fund Project of China Three Gorges University (Project Number: 2023kjzx001)

Disclosure statement

The authors declare no conflict of interest.

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