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REVIEW

Research Status and Development Trends of Blended Learning in Mathematics Education: A Knowledge Mapping Analysis Using CiteSpace

Estado de la investigación y tendencias de desarrollo del aprendizaje mixto en la educación matemática: un análisis de mapeo del conocimiento utilizando CiteSpace

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ABSTRACT

Introduction: blended learning has emerged as a prominent area of research in the field of education, with particular interest in its application to mathematics education.
Objective: this study aims to systematically explore the research status and development trends of blended learning in mathematics education.
Methods: this study utilized 419 journal articles on blended learning in mathematics education, published in the Web of Science Core Collection from 2004 to 2024, as the research sample. Guided by the PRISMA framework, statistical and bibliometric analysis methods were employed. CiteSpace software was used to visualize knowledge maps, including authors, countries, and keyword timeline views, providing a comprehensive analysis.
Results: the study showed that current research on blended learning in mathematics education is in a rapid development stage, with a loose network of collaborating authors, and that the United States has the largest number of published papers in the field of blended learning research in mathematics education, with a strong international impact. The research results were mainly published in *Computers & Education*, *International Journal of Educational Technology in Higher Education* and other journals. Blended learning in mathematics education research, from initial exploration to application extension to deeper integration with technology, showed a trend of development from conceptual framework building to strategy application to technology driven.
Conclusions: this study provides valuable insights for educators and researchers to improve the effectiveness and validity of blended learning implementation in mathematics education.

Keywords: Blended Learning; Maths Education; CiteSpace; Knowledge Mapping.

RESUMEN

Introducción: el aprendizaje combinado se ha convertido en un área de investigación destacada en el campo de la educación, con un interés particular en su aplicación a la educación matemática.
Objetivo: este estudio tiene como objetivo explorar sistemáticamente el estado de la investigación y las tendencias de desarrollo del aprendizaje combinado en la educación matemática.
Métodos: este estudio utilizó 419 artículos de revistas sobre el aprendizaje combinado en la educación matemática, publicados en la Web of Science Core Collection entre 2004 y 2024, como muestra de investigación. Siguiendo el marco PRISMA, se emplearon métodos de análisis estadístico y bibliométrico. Se

utilizó el software CiteSpace para visualizar mapas de conocimiento, incluyendo autores, países y vistas de la línea de tiempo de palabras clave, proporcionando un análisis completo.
Resultados: el estudio mostró que la investigación actual sobre el aprendizaje combinado en la educación matemática se encuentra en una etapa de desarrollo rápido, con una red de autores colaboradores aún dispersa, y que estados unidos tiene el mayor número de artículos publicados en el campo de la investigación sobre el aprendizaje combinado en la educación matemática, con un fuerte impacto internacional. los resultados de la investigación se publicaron principalmente en revistas como *Computers & Education, International Journal of Educational Technology in Higher Education* y otras. la investigación sobre el aprendizaje combinado en la educación matemática, desde la exploración inicial hasta la extensión de su aplicación y la integración más profunda con la tecnología, mostró una tendencia de desarrollo que va desde la construcción de marcos conceptuales hasta la aplicación de estrategias y, finalmente, hacia un enfoque impulsado por la tecnología.
Conclusiones: este estudio proporciona valiosas ideas para educadores e investigadores para mejorar la efectividad y validez de la implementación del aprendizaje combinado en la educación matemática.

Palabras clave: Aprendizaje Combinado; Educación Matemática; Citespace; Mapeo Del Conocimiento.

INTRODUCTION

Blended learning is a new teaching model that integrates face-to-face teaching experiences with online learning experiences to best address different problems and needs. It integrates the advantages of traditional classroom learning and information technology-supported online learning, which can significantly improve student learning outcomes in higher education.[1] With the advancement of network technology and the advent of the information technology era, which has brought new opportunities for the reform and development of mathematics education, the blended learning model, which combines traditional offline lectures with online learning on the Internet, is being applied to many disciplines in mathematics education.[2] The emergence of blended learning combines the advantages of offline face-to-face teaching and learning from online resources, and plays a positive role in promoting learners' personalised learning.[3] At present, some progress has been made in the research related to the development of blended learning in the field of mathematics education. In order to better understand the relevant research findings, this study conducts a visual analysis of the literature related to the development of blended learning in the field of mathematics education, and reveals the current status and development trend of the research on blended learning in the field of mathematics education, with the aim of supporting the further practice and research of teaching reform in the field of mathematics education.

The objective of this study is to examine the current state and emerging trends in research on blended learning in mathematics education using CiteSpace knowledge mapping. This includes analyzing the publication volume, author collaborations, national collaborations, and highly cited papers, followed by an investigation into research trends using keyword burst detection and timeline mapping.

METHOD

Research design

CiteSpace is a software tool developed by a team led by Professor Chaomei Chen at Drexel University, designed for the visualization and analysis of scientific literature. It displays the research evolution and trends within a specific field in the form of knowledge maps, enabling researchers to conduct intuitive analyses and gain an overall understanding of the research domain.[4] This paper used CiteSpace, v. 6.4.R1 to generated knowledge graphs such as authors, country collaboration maps, timeline views, etc. to explore the current state and trends of research related to blended learning in the field of mathematics education.The study framework is shown in figure 1 below.

Literature search

The data employed in the econometric analyses presented in this paper were sourced from the Institute for Scientific and Technological Information (ISI) Web of Science (WOS) core database, using an 'advanced search' with the following search terms. TS=((“blended learn*”OR “blended course” OR “blended teach*” OR “hybrid learning” OR “Mixed-model instruction” OR “blended education” OR “Web-enhanced instruction” OR “blended e-learning” OR “Technology-mediated instruction” OR “blended instruction” OR “B-learning”) AND (“Mathematics Education” OR “Mathematics”)).[5,6] The time span was 2004-2024 and the search was conducted on 1 November 2024. The preliminary search yielded 462 documents to ensure the accuracy and comprehensiveness of the literature data, and the titles, abstracts, keywords, etc. of the documents obtained

from the preliminary search were read one by one, yielding 419 valid documents (the specific details of the screening are shown in figure 2).

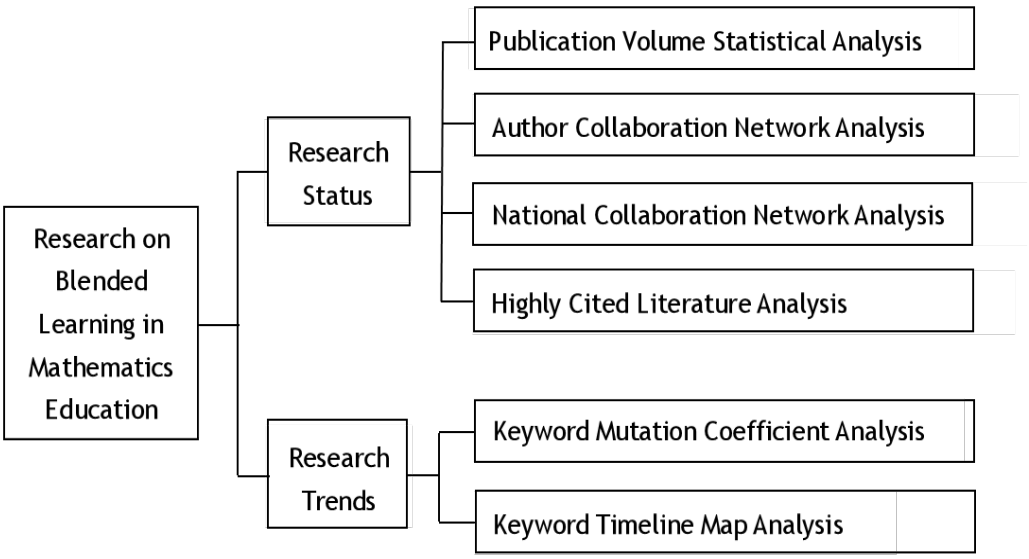

Figure 1. Research framework

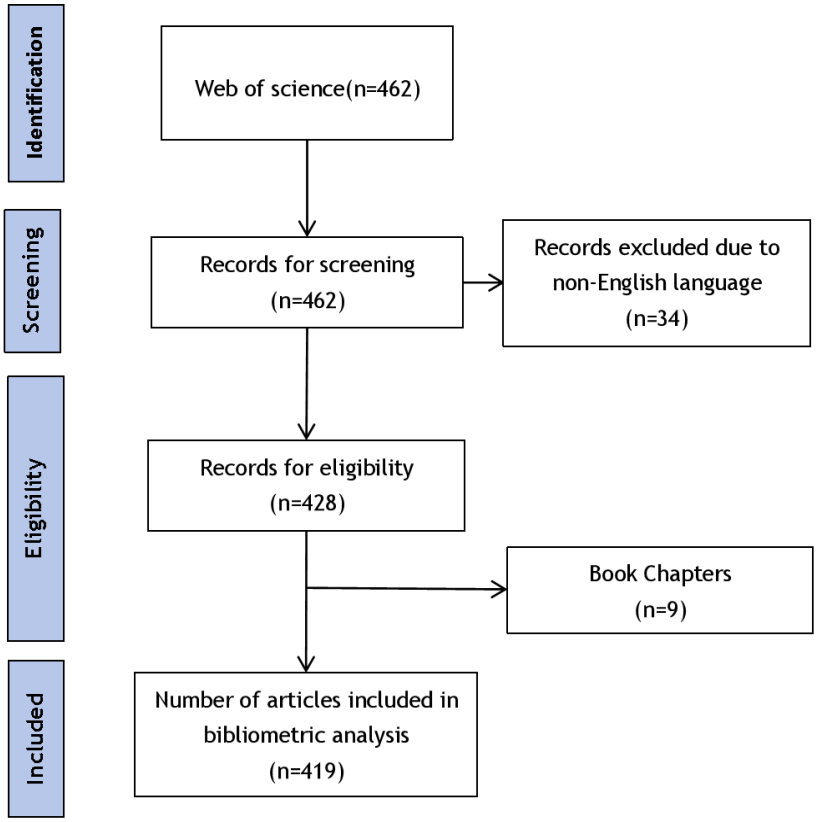

Figure 2. PRISMA flow diagram

RESULTS AND DISSCUSSION

Publication Volume Statistical Analysis

The annual increase or decrease of the publication volume of a certain field of literature can reflect to a certain extent the attention of researchers to the field.[7] To this end, the annual publication trend statistics of the above 419 blended learning in mathematics education research papers were carried out. It can be seen from Figure 1 that from 2004 to 2024, the number of publications about blended learning in the field of mathematics

education shows an overall increasing trend, which can be divided into two stages: before 2009, the number of publications is relatively small and the growth is slow, which is in the stage of preliminary exploration; from 2009 onwards, the number of publications increases significantly and the growth rate is fast, and the relevant research in this field heats up rapidly, and reaches the peak in 2022 (45 publications), after which it decreases slightly but still remains high. The above shows that the number of articles published on blended learning in mathematics education is relatively small and stable from 2004 to 2009, which is a gestation period; the number of articles published from 2010 to 2024 has been increasing at a higher rate year by year, the study of blended learning in mathematics education has gradually gained greater attention and emphasis from scholars.

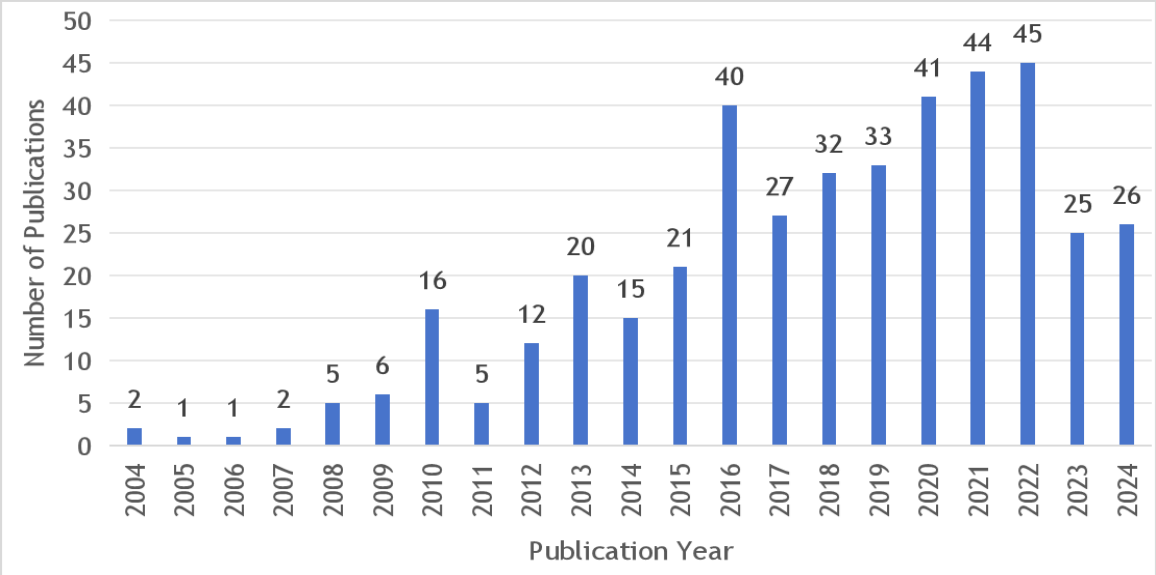

Figure 3. Blended learning in mathematics education research publication statistics

Author collaborative network analysis

CiteSpace's author co-occurrence analysis allows for the identification of the core scholars in a given research area, as well as the revelation of collaborations and cross-citations between researchers.[8] Figure 4 shows the author's collaborative network mapping with 392 nodes and 254 links with a network density of 0,0033. The network density was low, which indicated that the co-operation between the core authors is loose. According to Price's law, authors with more than or equal to 3 publications are the core authors in the field of blended learning research in mathematics education. According to CiteSpace, a total of 14 core authors have contributed 48 publications, representing 11,5 % of the overall number of publications in the field.

In this map, researchers such as Engelbrecht, Johann; Baker, Ryan S.; Borba, Marcelo C.; and Figueiredo, Mauro are located within larger clusters with numerous nodes and connections, indicated that they are active contributors in this field and have formed closely-knit collaborative networks. Also, these larger clusters show more partners, reflecting their significant influence in the field of blended learning mathematics. Comparatively, smaller clusters such as Lopes, Ana Paula and Guiza, M showed some collaboration but are relatively small.

Although the figure demonstrates a large number of active researchers, the centrality value of all authors is 0,00, which means that these researchers do not play a bridging role in the network. This phenomenon may reflect the fragmented nature of blended learning collaborations in mathematics education and the lack of a unified core group or central figure, suggesting that the collaborative relationships between the researchers are relatively shallow and do not have deep or broad connectivity.

National cooperation network analyses

A visualisation of the literature data from the Web of Science Core Collection database, with countries as nodes, resulted in a visualisation map with 71 nodes and 99 connecting lines (figure 5).

The map showed that although there are several countries and regions involved in the research of blended learning in mathematics education, the quantity and quality of articles vary. The outer circle of the chronology represented the United States (USA) was purple and has the largest area, with a centrality of 0,33, and the number of publications was 47, ranking the first in the world, which indicated that the research on blended learning in mathematics education in the United States has a high academic influence; although the number of publications in Norway was only 12, which was not in the top five, its centrality was 0,18, ranking the fourth; the number of publications in China was 29, ranking the fourth, but the centrality was only 0,05, which made its international influence weaker.

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Meanwhile, USA has more connections with several countries, such as Germany, Peoples R China, Spain, and England, suggesting frequent and close co-operation between these countries. In addition, China, England, South Africa, and Spain were also larger nodes, suggested that they have also made important research contributions to blended learning mathematics education. Peoples R China has strong collaborations with Asian countries such as Indonesia, South Korea, and so on, which showed China's collaboration within the Asian regional network.

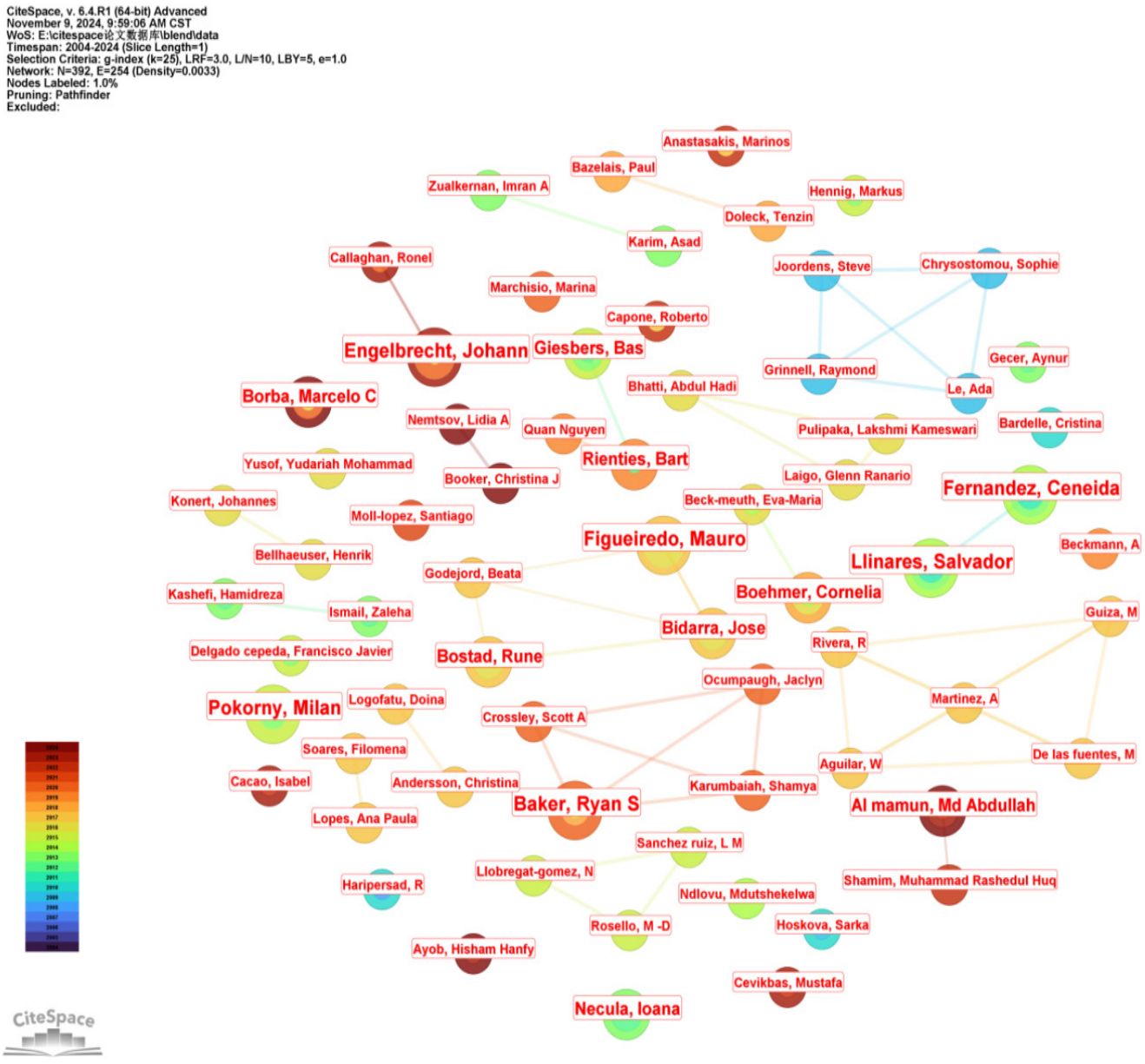

Figure 4. Author collaboration knowledge map

Highly Cited Literature Analysis

The publication of highly cited papers indicates the emergence of new scholarship in the time period of their study or new breakthroughs in research in their field.[9] Table 1 lists the top 8 cited articles for the period 2004-2024. These articles were mainly published in 2012 and around 2021, and all of them have been cited more than 55 times. Henrie, CR and Bond, M are the main cited authors, and Henrie, CR's articles have been cited 443 times, while Bond, M's articles have been cited 293 times. A study of these scholars' papers revealed that the use of blended learning in mathematics education has grown rapidly in recent years, especially in the context of digital technology and educational technology.

The cited literature mainly came from Computers & Education, International Journal of Educational Technology in Higher Education, Educational Technology & Society, the Educational Technology Research and Development (ETR&D) and other academic journals, which are the main publishing journals for the results of research on blended learning mathematics education.

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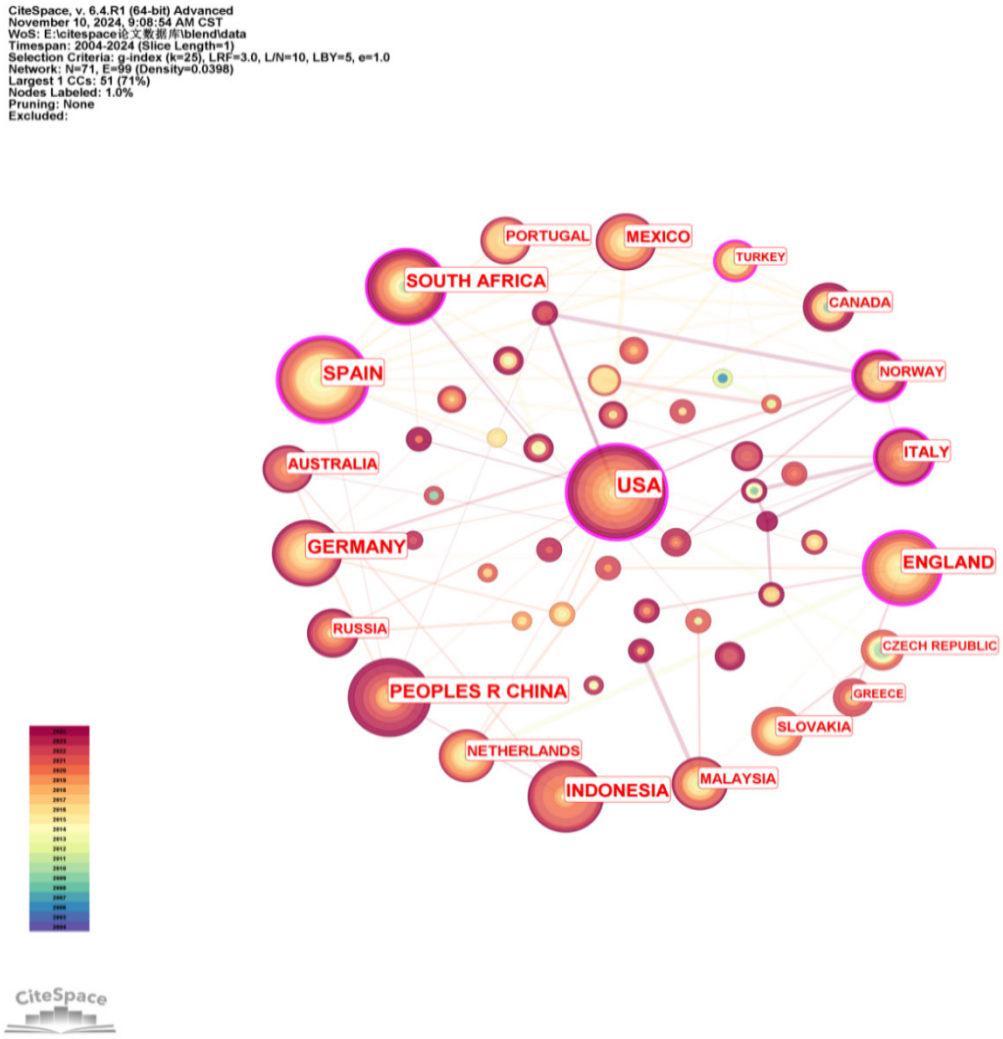

Figure 5. Country cooperation analysis map

Table 1. Top 8 most cited papers in the web of science core collection database

No.	Title	Author	Journal	Year	Citations
1	Measuring student engagement in technology-mediated learning: A review	Henrie, CR	COMPUTERS & EDUCATION	2015	443
2	Mapping research in student engagement and educational technology in higher education:a systematic evidence map	Bond, M	INTERNATIONAL JOURNAL OF EDUCATIONAL TECHNOLOGY IN HIGHER EDUCATION	2020	293
3	Effects of the flipped classroom instructional strategy on students' learning outcomes: a meta-analysis	Cheng, L	ETR&D-EDUCATIONAL TECHNOLOGY RESEARCH AND DEVELOPMENT	2019	224
4	Flipping a College Calculus Course: A Case Study	Sahin, A	EDUCATIONAL TECHNOLOGY & SOCIETY	2015	115
5	Blended learning, e-learning and mobile learning in mathematics education	Borba, MC	ZDM-MATHEMATICS EDUCATION	2016	87
6	Transformation of the mathematics classroom with the internet	Engelbrecht, J	ZDM-MATHEMATICS EDUCATION	2020	74
7	Past, present, and future of smart learning: a topic-based bibliometric analysis	Chen, XL	INTERNATIONAL JOURNAL OF EDUCATIONAL TECHNOLOGY IN HIGHER EDUCATION	2021	69
8	How achievement emotions impact students' decisions for online learning,and what precedes those emotions	Tempelaar, DT	INTERNET AND HIGHER EDUCATION	2012	69

Keyword Mutation Coefficient Analysis

Keyword mutation coefficient refers to a sudden increase or decrease in the occurrence of a keyword in a

certain period of time, which represents the frontier of the research field and the direction of trend shift.[8] It can be observed that an increase in the intensity of the mutation coefficient is associated with a corresponding increase in the percentage change in the key word's frequency within the specified time period. Mutation coefficient detection is carried out using CiteSpace (as shown in Figure 6), and 14 mutated words were selected from relevant studies on blended learning in mathematics education between 2004 and 2024.

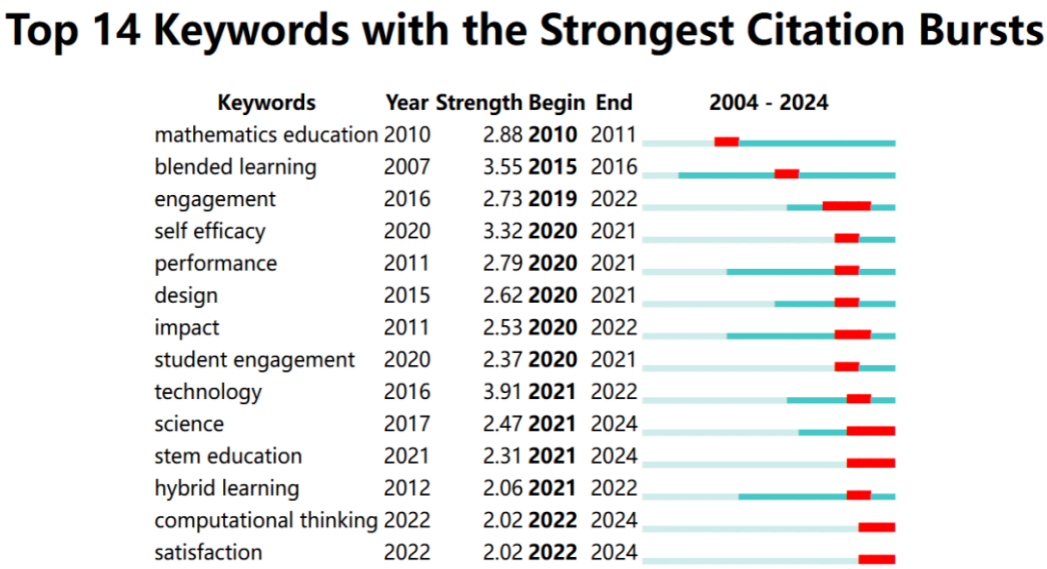

Figure 6. Top 14 keywords with the strongest citation bursts

According to figure 6, the evolution trend of blended learning in mathematics education from 2004 to 2024 can be divided into three stages.

The initial phase, spanning the years 2004 to 2015, saw a predominant focus on mathematics education and blended learning. The aforementioned keywords indicated that, in the initial phase, researchers were primarily concerned with the introduction and preliminary implementation of the concepts of "mathematics education" and "blended learning". The low intensity and brief duration of keyword mutation at this stage suggested that the implementation of blended learning in the context of mathematics education remains in its infancy and has yet to garner significant attention. Furthermore, the mutation intensity of "blended learning" is considerable, suggesting that the focus of research at this time may be on exploring the introduction of the blended learning model in mathematics education and on combining traditional teaching with online resources.

The second phase, 2016-2020, saw a rapid increase in research on blended learning in mathematics education, with a notable shift in focus towards specific teaching and learning outcomes and student responses in blended learning. This phase saw the emergence of new keywords such as "engagement", "self-efficacy", "performance", "design", "impact", and "student engagement", reflecting a gradual shift in emphasis by researchers towards these areas. Meanwhile, the mutation time of the keywords has been prolonged and the intensity of the mutation has increased, reflecting the gradual deepening of the application of blended learning in the field of mathematics education and the beginning of a focus on its specific impact on students' learning effectiveness and engagement.

In the third phase, spanning the period from 2021 to 2024, a number of topics have emerged as key areas of interest within the field of mathematics education. The research topics of "technology", "science", "stem education", "hybrid learning", "computational thinking", and "satisfaction", among others, have emerged as the focal points of inquiry in the field of mathematics education. Among these, "technology" has emerged as a particularly salient keyword, exhibiting a mutation intensity of 3,91 in recent years. It is therefore regarded as one of the most pivotal research areas in the field of mathematics education in recent times. Concurrently, the elevated mutation time and mutation intensity indicated that researchers were not only concerned with the efficacy of teaching methods, but also with the implementation of innovative technologies and interdisciplinary integration in blended learning. Furthermore, the topic of student satisfaction has emerged as a significant area of investigation.

Keyword Timeline Map Analysis

The Timeline view area of CiteSpace software is used to generate a timeline map of keywords in blended learning research in mathematics education (Figure 7), so as to better depict and display the evolution and time

trajectory of the important keywords in each clustering module, to show the temporal distribution of related studies and their interrelationships, and to identify the progress of blended learning research in mathematics education. The research trend of blended learning in mathematics education from 2004 to 2024 is divided into three phases: initial exploration of research, expansion of application, and deepening of integration with technology.

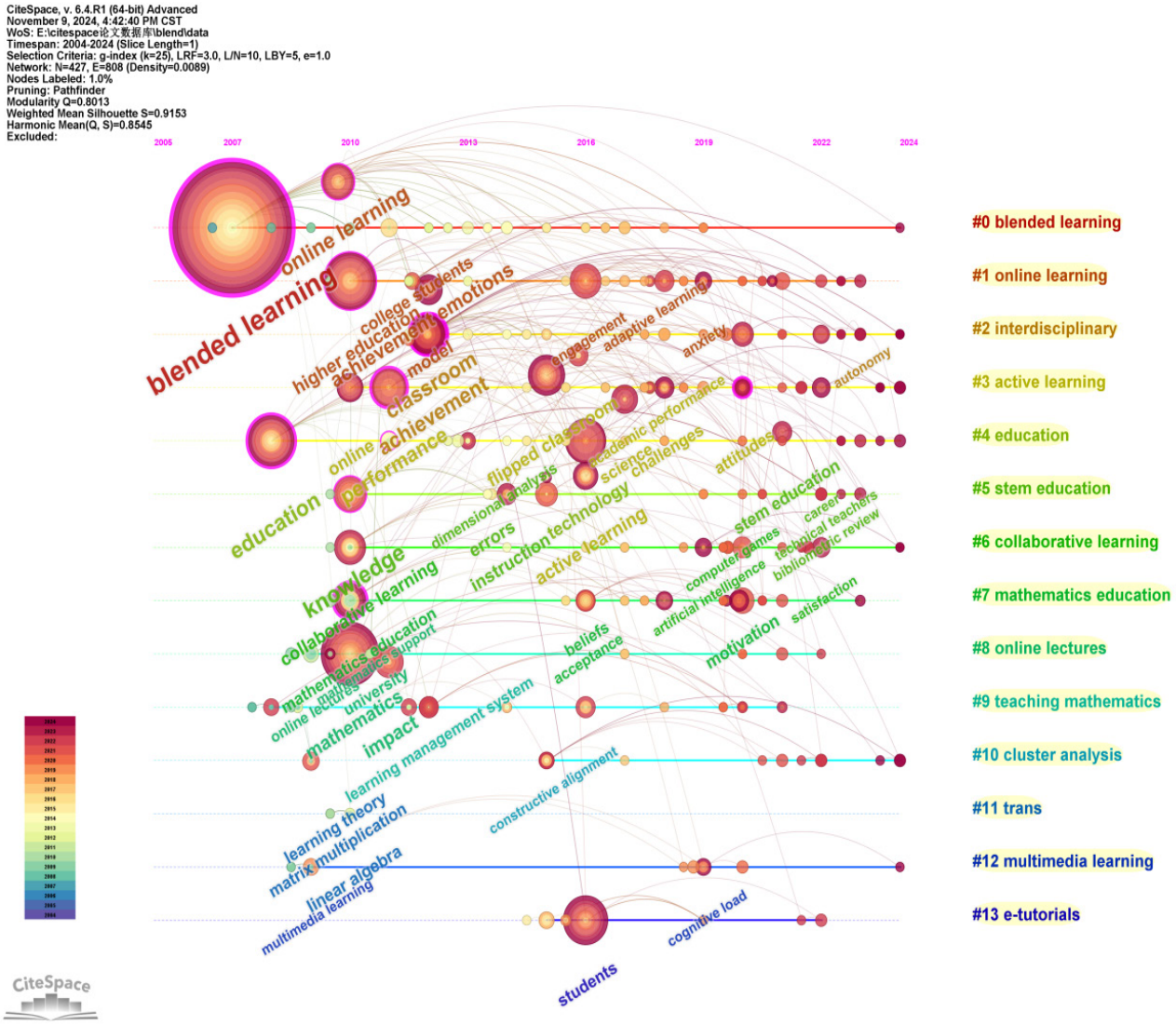

Figure 7. Timeline mapping of keywords in blended learning mathematics education research

The first stage was the initial exploration stage of blended learning in mathematics education research (2004-2012). At this stage, the research on blended learning in mathematics involves few keywords and a small number of articles, and the research mainly focuses on the connotation of the concept of blended learning, its manifestations and value and significance. Represented by Bouniaev's[10] paper "Math on the web for online and blended teaching: Learning theories perspectives", although there were fewer keywords at that stage, "blended learning", "online learning", "higher education", "instructional strategy", "mathematics education", and "instructional strategy", "mathematics education" and other key terms in the field have emerged. Keywords such as "blended learning" and "online learning" show that researchers are trying to explore the feasibility and effectiveness of introducing online education into traditional teaching, especially in higher education.[11] The research at this stage is mostly exploratory, focusing on how to construct the basic framework of blended learning and effective teaching strategies, laying the foundation for the in-depth research at subsequent stages.

The second stage was the expansion of the application of blended learning in mathematics education research (2013-2019). In this phase, the number of keywords involved increased significantly and the number of related articles increased rapidly, and the keywords with high word frequency mainly pointed to the topic of blended learning and mathematics education, and the keywords included were mainly "flipped classroom", "active

learning", "motivation", "engagement", "collaborative learning", "instructional strategy", "knowledge", "university", "learning strategy". Since 2013, blended learning research has been gradually expanding, and emerging pedagogical approaches such as flipped classroom and active learning have become the focus of attention. Sahin et al.[12] explored the influence of the flipped classroom model on college calculus students' preparation, understanding, and performance. The results showed that students preferred the flipped classroom model for course preparation and that it is effective in improving their academic achievement. Cheng et al.[13] explored the effectiveness of flipped classroom instructional strategies on student learning outcomes, and the results showed that the flipped classroom had a positive impact on student learning outcomes. Baragash & Al-Samarraie[14] specifically explored the impact of student engagement in multiple learning delivery models on student performance. This phase also saw the introduction of a more strategic approach to teaching and learning, which began to focus on how to enhance student learning outcomes and knowledge construction. Taken together, it can be seen that researchers are beginning to emphasise student motivation and classroom engagement, and exploring the use of collaborative and active learning in blended learning.

The third stage was the deepening of blended learning in mathematics education research and technology integration (2020 - 2024). In this stage, the number of keywords in blended learning in mathematics education research grows rapidly, and a large number of new research themes and keywords emerge, "digital learning", "academic performance", "artificial intelligence", "challenges", "autonomy", "satisfaction", "STEM education", "anxiety", "learning management system". After 2020, blended learning research enters a deepening phase driven by technology. The introduction of digital learning and artificial intelligence technologies has become a new focus of research, with researchers focusing more on how emerging technologies can be used to address various challenges in blended learning, improve student academic performance, and enhance student autonomy and satisfaction. Bond et al.[15] found that educational technology has the potential to improve students' behavioral, affective, and cognitive aspects, emphasizing the performance and pointed out directions for future research. Iqbal et al.[16] investigated the use and development of augmented reality (AR) technology in STEM education. The study found an increasing use of AR technology in education and a greater trend towards technology-enhanced learning. Sánchez-Ruiz et al.[17] explored the potential of using ChatGPT for b-learning mathematics in engineering education. The results showed that the combination of blended learning methods in and ChatGPT increased students' confidence, it is also found that teaching strategies and methods need to be adapted to ensure the development of critical skills for career development. In addition, the emergence of these keywords suggests that blended learning is gradually merging with interdisciplinary education and being applied in personalised learning environments to drive further developments in mathematics education.

CONCLUSIONES

The research on blended learning in mathematics education demonstrates a discernible upward trajectory, indicative of a growing scholarly interest in this field. Although the author collaboration network is relatively loose, the United States occupies a dominant position in international cooperation. Highly cited papers are primarily published in authoritative journals such as Computers & Education, which serves to highlight the concentration of research outcomes in these key platforms. The development trends indicate that technology integration and student performance have become the primary focus of research. A keyword timeline analysis reveals a shift from initial exploration to deeper integration of technology. These findings provide valuable insights for a deeper understanding of the application of blended learning in mathematics education and offer important directions for future research, particularly in the areas of innovative technology integration and optimising teaching effectiveness.

REFERENCES

1. Attard C, Holmes K. An exploration of teacher and student perceptions of blended learning in four secondary mathematics classrooms. Mathematics Education Research Journal [Internet]. 2022 Dec;34(4):719-40. Available from: https://doi.org/10.1007/s13394-020-00359 -2

2. Kadirbayeva R, Pardala A, Alimkulova B, Adylbekova E, Zhetpisbayeva G, Jamankarayeva M. Methodology of Application of Blended Learning Technology in Mathematics Education. Cypriot Journal of Educational Sciences [Internet]. 2022;17(4):1117-29. Available from: https://doi.org/10.18844/cjes.v17i4.7159

3. Alsalhi NR, Al-Qatawneh S, Eltahir M, Aqel K. Does blended learning improve the academic achievement of undergraduate students in the mathematics course?: A case study in higher education. EURASIA Journal of Mathematics, Science and Technology Education [Internet]. 2021 Mar 18;17(4):em1951. Available from: https://doi.org/10.29333/ejmste/10781

4. Chen C. CiteSpace: a practical guide for mapping scientific literature [Internet]. New York: Nova

Science Publishers, Inc; 2016.(Computer science, technology and applications). Available from: https://www.researchgate.net/publication/308204148

5. Jing M, Qian Z. The focus and trends of international blended learning research: An Empirical analysis based on mapping knowledge domain. Journal of East China Normal University (Educational Sciences) [Internet]. 2019 Jul 20;37(4):116. Available from: https://doi.org/10.16382/j.cnki.1000-5560.2019.04.011

6. Özdemir A. Research Trends of Flipped Classroom Model in Mathematics Education: A Bibliometric Mapping Analysis. Anadolu Journal of Educational Sciences International [Internet]. 2024 Jul 1;14(2):793-819. Available from: https://doi.org/10.18039/ajesi.1310050

7. Chen X, Zou D, Xie H, Wang FL. Past, present, and future of smart learning: a topic-based bibliometric analysis. International Journal of Educational Technology in Higher Education [Internet]. 2021 Jan 15;18(1):2. Available from: https://doi.org/10.1186/s41239-020-00239-6

8. Chen C. Information visualization. Wiley Interdisciplinary Reviews: Computational Statistics [Internet]. 2010 Jul;2(4):387-403. Available from: https://doi.org/10.1002/wics.89

9. Wang W, Lu C. Visualization analysis of big data research based on Citespace. Soft Computing [Internet]. 2020 Jun;24(11):8173-86. Available from: https://doi.org/10.1007/s00500-019-04384-7

10. Bouniaev M. Math on the web for online and blended teaching: Learning theories perspectives. In: Cantoni L, McLoughlin C, editors. Proceedings of ED-MEDIA 2004--World Conference on Educational Multimedia, Hypermedia & Telecommunications [Internet]. Lugano, Switzerland: Association for the Advancement of Computing in Education (AACE); 2004. p. 3816–21. Available from: https://www.learntechlib.org/primary/p/12069/

11. Inglis M, Palipana A, Trenholm S, Ward J. Individual differences in students' use of optional learning resources. Journal of Computer Assisted Learning [Internet].2011 Dec;27 (6):490-502. Available from: https://doi.org/10.1111/j.1365-2729.2011.00417.x

12. Sahin A, Cavlazoglu B, Zeytuncu YE. Flipping a college calculus course: A case study. Journal of Educational Technology & Society [Internet]. 2015 Jul 1;18(3):142-52. Available from: https://www.jstor.org/stable/10.2307/jeductechsoci.18.3.142

13. Cheng L, Ritzhaupt AD, Antonenko P. Effects of the flipped classroom instructional strategy on students' learning outcomes: A meta-analysis. Educational Technology Research and Development [Internet]. 2019 Aug 15;67:793-824. Available from: https://doi.org/10. 1007/s11423-018-9633-7

14. Baragash RS, Al-Samarraie H. Blended learning: Investigating the influence of engagement in multiple learning delivery modes on students' performance. Telematics and Informatics [Internet]. 2018 Oct 1;35(7):2082-98. Available from: https://doi.org/10.1016/j.tele.2018.07.010

15. Bond M, Buntins K, Bedenlier S, Zawacki-Richter O, Kerres M. Mapping research in student engagement and educational technology in higher education: A systematic evidence map. International journal of educational technology in higher education [Internet]. 2020 Dec;17:1-30. Available from: https://doi.org/10.1186/s41239-019-0176-8

16. Iqbal MZ, Mangina E, Campbell AG. Current challenges and future research directions in augmented reality for education. Multimodal Technologies and Interaction [Internet]. 2022 Sep 1;6(9):75. Available from: https://doi.org/10.3390/mti6090075

17. Sánchez-Ruiz LM, Moll-López S, Nuñez-Pérez A, Moraño-Fernández JA, Vega-Fleitas E. ChatGPT challenges blended learning methodologies in engineering education: a case study in mathematics. Applied Sciences [Internet]. 2023 May 14;13(10):6039. Available from: https://doi.org/10.3390/app13106039

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