Journal of Education, Teaching and Social Studies
ISSN 2642-2336 (Print) ISSN 2642-2328 (Online)
Vol. 6, No. 3, 2024
www.scholink.org/ojs/index.php/jetss

Original Paper

A Route Analysis Study of Artificial Intelligence Enabling Education—Visualization Analysis Based on Citespace Literature Keywords

Zhixue Tao[1], Mengfan Li[2], Xiaoshuang Xu[3], Jun Zhang[4], Gui Chen[5]

Huanggang Normal University, Huanggang City, Hubei Province, China

Received: July 16, 2024 Accepted: August 19, 2024 Online Published: August 28, 2024

doi:10.22158/jetss.v6n3p144 URL: http://dx.doi.org/10.22158/jetss.v6n3p144

Abstract

With the advent of the intelligent era, artificial intelligence technology promotes the innovation and development of the education field. Based on the data in Web of Science database and CNKI database, the article uses Citespace software to construct keyword co-occurrence network mapping, keyword clustering mapping, keyword emergence map, etc. to visualize and analyze the data, and sort out the domestic and international research hotspots, themes, and trends of educational artificial intelligence. It is found that the current research on AI in education in China can be categorized into three major themes: research on empowering education based on technological support, AI for educational change, and research on the application and impact of AI in education; while the research results on AI in education abroad mainly focus on two major themes: case studies on the application of machine learning, and research on the way of focusing on people's teaching/learning based on technological support. The article presents and analyzes the hotspots, themes and trends of domestic and foreign educational artificial intelligence research visually, with a view to understanding the current status of domestic and foreign educational artificial intelligence research, grasping the current research hotspots, themes and trends, finding the differences and connections between domestic and foreign research, and thus putting forward useful references to the development of educational artificial intelligence in China.

Keywords

educational AI, artificial intelligence, visualization, Citespace

1. Introduction

At present, countries are vigorously promoting the digital transformation of education, which is an inevitable trend of educational innovation and development. With the continuous development of intelligent technology, the importance of "Artificial Intelligence + Education" is becoming more and more prominent. Educational artificial intelligence is a new field combining artificial intelligence and learning science, using artificial intelligence technology to optimize the educational ecosystem and promote the innovation and development of education (Yan, Tang, & Qin, 2017). After decades of research in China has formed the theory and practice mode of intelligent education with Chinese characteristics (Zhu, Lu, & Wang, 2023), but the research on the technological development and realistic application of artificial intelligence in education is relatively weak, and can not be closely integrated with the actual situation of education (Cui & Ma, 2023), it is necessary to further explore the current situation of educational artificial intelligence in China. In addition, although Zhang Rongfei and other scholars visualized and analyzed the development status of educational artificial intelligence in foreign countries as early as 2019, in the era of rapid technological innovation, it is still necessary to keep up with the forefront of the times and learn about the latest development of educational artificial intelligence at home and abroad at present.

Based on this, this study utilizes Citespace visual knowledge mapping, by comparing domestic and international research related to educational artificial intelligence, with a view to understanding the current status of domestic and international research on educational artificial intelligence, grasping the current research hotspots, themes and trends, finding the differences and connections between domestic and international research, and proposing useful reference for the development of educational artificial intelligence in China.

2. Research Methodology

2.1 Research Tools

Citespace is a visual analysis tool developed by Professor Chaomei Chen (2016) with an eye to analyzing the potential knowledge embedded in scientific analysis, and its main function is to detect and analyze research frontiers and research hotspots based on knowledge mapping (Hou & Hu, 2013). In this study, Citespace is used to draw a visualized knowledge map, and keyword co-occurrence, keyword clustering, keyword emergence and other methods are used to quantitatively analyze domestic and international research results about educational artificial intelligence, and sort out the current domestic and international research status in this area.

2.2 Data Sources

This paper uses Web of science (WOS) database and China Knowledge Network (CNKI) academic journals as the data source. The WOS database uses "Educational Artificial Intelligence" or "Intelligent Teaching Agent" or "Natural Language Processing" or "Intelligent Tutoring System" or "Machine Learning" or "Man-machine cooperative teaching" as the theme, and the type of literature was selected

as "Article". Article, the search scope is the WOS core collection, by manually eliminating duplicated documents and documents not related to the topic of this study, we obtained a total of 1,063 valid documents. We selected "Artificial Intelligence in Education" or "Intelligent Teaching Agent" or "Natural Language Processing" or "Intelligent Instructional System" or "Intelligent Instruction System" as the main topic of the search or "machine learning" or "human-computer collaborative teaching" or "intelligent education" as the theme, and the search scope was Beida Core, CSSCI and CSCD, and CSCD, through manual elimination and screening, a total of 1,709 effective documents were obtained.

2.3 Data Processing

Before analyzing the collected data using Citespace, the node type is Keywords, the Link Strength parameter is Cosline algorithm, and the Pruning method is Pathfinder, which is a path finding algorithm that prunes the research network, filtering out the unimportant nodes and edges in the network structure and retaining the strongest connections important nodes and edges in the network structure and retain the strongest connections.

Its main data processing analysis process is:

(1) Produce keyword co-occurrence network mapping, analyze its keyword citation frequency and centrality;

(2) Further clustering the co-occurrence network atlas to form a keyword clustering atlas, and determining the current research themes of educational artificial intelligence in the past five years by further analyzing the existing classic literature;

(3) Understand the current research trends by analyzing keyword emergence;

(4) To compare the research themes and research trends of educational artificial intelligence at home and abroad.

3. Visual Presentation and Analysis of Domestic Research Hotspots

Keywords are the essence of an article, and keyword covariance analysis can be used to understand the correlation between high-frequency keywords and high-frequency keywords, and the higher the frequency of keywords, the more likely they are to reveal the current research hotspots.

3.1 Keyword Co-occurrence Network Analysis

As shown in Figure 1, it is a knowledge graph of keyword co-occurrence analysis for domestic educational AI. The connectivity between the nodes is high, and the co-occurrence relationship is strong, while multiple nodes act as a bridge between subgroups. The larger the node indicates the higher frequency of the keyword, in order of node size: artificial intelligence, artificial intelligence education, artificial intelligence era, human-computer collaboration, teacher professional development, talent training, vocational education, machine learning, educational change, higher education, ethical risk, big data, deep learning, smart education, education, education AI are the hot issues of education of AI in China in the past 5 years.

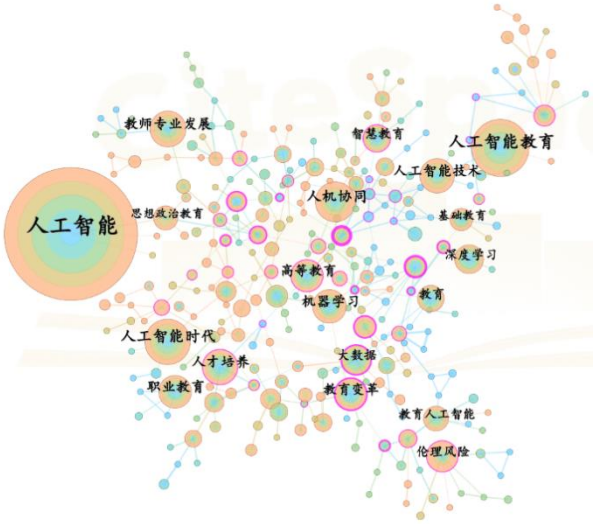

Figure 1. Keyword Co-occurrence Knowledge Graph of CNKI Educational AI

Also mediated centrality of keywords is a graph theoretical concept used to quantify the position of a point in a network set and can show the structure and dynamic nature of the domain (Li & Zhou, 2018). If the node frequency is high but the centrality is 0, it cannot be treated as a key node (Wang, Yu, & Huang, 2015), and in general mediated centrality greater than 0.1 is a key node. As shown in Table 1, it is the keyword frequency and centrality statistics of educational AI research, and the top 40 are shown in order of frequency. Among them, the top 5 centrality rankings are Horizon Report (0.77), Educational Robotics (0.44), Educational Change (0.39), Artificial Intelligence Literacy (0.39), and Educational Informatization (0.34), which indicates the focus of the current research in this field. From this, we can also know that the Horizon Report is the most important way for domestic scholars to understand the current research trends and key technologies in the field of education, and it is also the focus of domestic scholars.

Table 1. Keyword Frequency and Centrality Statistics of CNKI Research on Artificial Intelligence in Education (Partial)

Frequency	Centrality	Year	Keywords	Frequency	Centrality	Year	Keywords
821	0.03	2019	人工智能	22	0.39	2019	人工智能素养
157	0.01	2019	人工智能教育	22	0.06	2020	未来教育
100	0.03	2019	人工智能时代	22	0.14	2019	个性化学习
79	0.04	2019	人机协同	22	0.07	2020	教学改革
65	0.07	2019	教师专业发展	21	0.09	2019	新工科
60	0.18	2019	人才培养	19	0.03	2019	教育技术
58	0.09	2019	人工智能技术	17	0.04	2019	劳动教育

57	0.07	2019	职业教育	17	0.05	2019	教育应用
56	0.07	2019	机器学习	17	0.2	2020	技术伦理
49	0.39	2019	教育变革	17	0.05	2019	产教融合
49	0.19	2019	高等教育	17	0.34	2019	教育信息化
48	0.11	2019	伦理风险	17	0.01	2019	教师角色
45	0.2	2019	大数据	16	0.44	2019	教育机器人
42	0.01	2019	深度学习	16	0.06	2019	核心素养
39	0.12	2019	智慧教育	15	0.06	2019	教育大数据
39	0.07	2019	教育	14	0.03	2022	数字化转型
37	0.06	2019	教育人工智能	13	0.18	2019	知识图谱
30	0.07	2020	思想政治教育	13	0.77	2019	地平线报告
27	0.04	2019	基础教育	13	0.21	2020	技术赋能
24	0.05	2019	学习分析	12	0.04	2021	赋能

3.2 Keyword Network Clustering Analysis

The keywords were further analyzed by clustering in order to clarify the current research status of educational AI in China. Generally when clustered Slihouette S = 0.9393 (>0.7) indicates a good clustering result, and Modularity Q = 0.8325 (>0.3), indicates a significant clustering structure. As shown in Figure 2, the 15 clusters studied in the last five years of journals are demonstrated. Table 2 demonstrates the information about the frequency of clustering keywords and cluster profile values for the top 15 CNKI clusters.

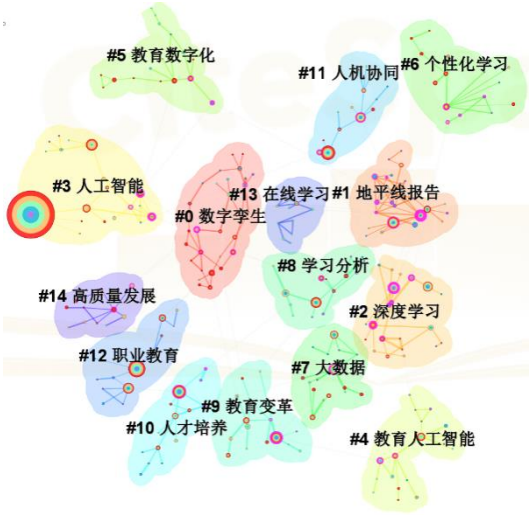

Figure 2. CNKI Educational AI Keyword Clustering (Partial)

Table 2. Top 15 Clustered Keywords of CNKI Educational Artificial Intelligence

cluster number	Clustering Keywords	frequency	Clustered mean contour values	Average year of publication
0	数字孪生	29	0.961	2021
1	地平线报告	24	0.852	2019
2	深度学习	21	0.962	2020
3	人工智能	20	1	2020
4	教育人工智能	18	0.937	2020
5	教育数字化	17	0.926	2021
6	个性化学习	16	0.968	2020
7	大数据	16	0.992	2020
8	学习分析	15	0.897	2019
9	教育变革	15	0.869	2020
10	人才培养	14	0.93	2020
11	人机协同	14	0.914	2020
12	职业教育	13	1	2020
13	在线学习	12	0.917	2020
14	高质量发展	11	1	2022

This study summarizes and categorizes these 15 clusters, and concludes that there are three main themes that are focused on in the domestic research results on AI in education: research on empowering education based on technological support, AI for educational change, and research on the application and impact of AI in the field of education.

(1) Research on empowering education based on technology support: including keyword clustering of digital twin, deep learning, artificial intelligence, big data, etc. Technology empowers teachers to teach, students to learn, school management and other educational fields, prompting technology and research to synergistically drive and jointly promote the development of high quality in education (Yuan, Zhang, & Lei, 2021). Among them, in the context of two-way empowerment of intelligent technology and education, artificial intelligence provides important kinetic energy for high-quality development of education (Hu, Sun, & Yang, 2022).

(2) Artificial Intelligence Technology for Educational Change: This includes education digitization, artificial intelligence in education, talent cultivation, human-computer collaboration, and industry-teaching integration. The use of artificial intelligence technology to promote teacher development, student learning, innovative talent training model, etc., to promote educational change is one of the current research themes in the field of education in China. Educational change is the process of technology-enabled education creation (Zhu & Hu, 2022). Artificial intelligence for educational

change mainly includes three realms: empowering education, innovating education, and reshaping education, and AI should be used as an endogenous variable for the overall change of education to promote the innovative development of education (Cao, 2020).

(3) Research on the application and impact of artificial intelligence in education: including learning analytics, online learning, personalized learning, and ethical risks. The application of artificial intelligence in the field of education involves basic education, higher education, vocational education and other levels. Among them, relatively more attention has been paid to the field of artificial intelligence in vocational education in the past five years. Chen Lijun and other scholars (2023) believe that the research of domestic scholars on vocational education is biased towards the use of "artificial intelligence + multifaceted technology" to promote the improvement of skills and reform the skills training system. In addition, since the release of ChatGPT, the research intensity of generative artificial intelligence (AIGC) in the field of education in China has continued to rise, and the ethical risks associated with it have become one of the current research directions.

3.3 Keywords Emergent Research Trends Frontier Analysis

Keyword emergence refers to the frequency of the sudden rise or fall of the keyword in a certain time period, which usually represents the shift direction of a certain research field (Chen, 2014). By analyzing the keyword emergent properties, we can understand the current research hotspots and research trend frontiers. Figure 3 shows the keyword emergence graph, taking the top six keywords in order of emergence intensity from high to low. As can be seen from Figure 3, in the past five years, China's education field has changed from using adaptive learning technology to focus on students' personalized learning to not only focusing on students' learning, but also focusing on teachers' personalized teaching; the use of a variety of information technology, including blockchain, AI and other technologies to empower education and the use of education AI in higher vocational colleges and universities has also become a hot spot of the current research and is likely to continue to develop towards the research in the future. The trend continues to develop. At the same time, to a certain extent, it also reflects that AI-enabled education relies on a series of AI underlying core technologies (Liang & He, 2023). With China's continuous attention to cutting-edge information technology, research trends are also changing closely with the changes in technology. From focusing on "blockchain + education" focusing on credit management, certificate management, etc., to the use of artificial intelligence to focus on students and teachers, also reflects the continuous progress and development of China's information technology field, reflecting the two-way empowerment of science and technology and education (Huang, Wang, & Jiao, 2021).

Top 6 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2019 - 2023
自适应学习	2019	3.04	2019	2020	
个性化教学	2021	2.74	2021	2023	
赋能	2021	2.46	2021	2023	
区块链	2019	2.12	2019	2020	
高职院校	2021	1.91	2021	2023	
信息技术	2020	1.86	2020	2021	

Figure 3. CNKI Keyword Emergence Map of Artificial Intelligence in Education

4. Visual Presentation and Analysis of Foreign Research Hotspots

For the production of foreign educational AI keyword-related maps, the operation is the same as the production process of domestic keyword knowledge maps.

4.1 Keywords Co-linear Network Analysis

As shown in Figure 4, it is the knowledge graph of keyword co-occurrence analysis of AI in education in foreign countries, which is sorted according to the size of the nodes: artificial intelligence, machine learning, students, education, intelligent tutoring system, achievement, learning analytics, natural language processing, online learning, modeling, and higher education are the hot issues of AI in education in foreign countries in the last 5 years.

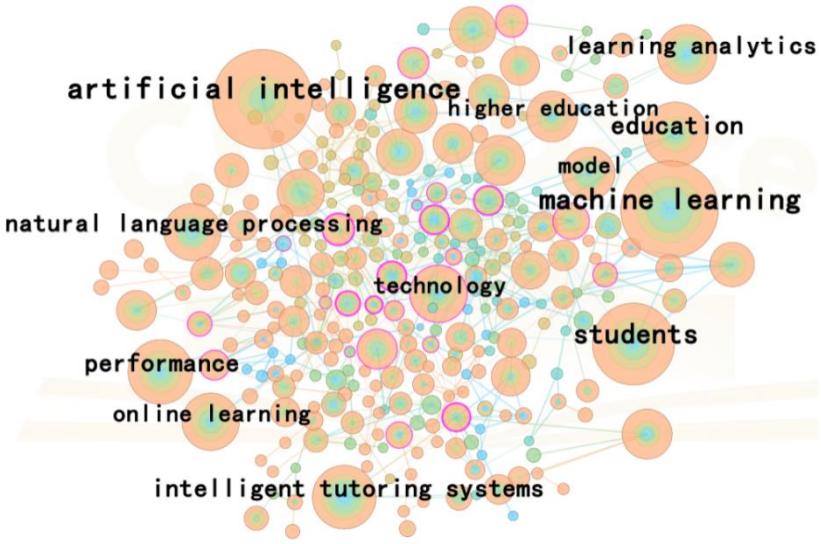

Figure 4. Keyword Co-occurrence Knowledge Graph for WOS Educational AI

Table 3 demonstrates the keyword frequency and centrality statistics of some foreign educational AI studies, showing the top 15 in order of frequency. Among them, the top 5 in centrality are cognitive load (0.39), mathematics (0.35), meta-analysis (0.27), academic achievement (0.23), and vision (0.21), indicating the focus of foreign educational AI research.

Table 3. Keyword Frequency and Centrality Statistics of WOS Educational AI Research (Partial)

Frequency	Centrality	Year	Keywords	Frequency	Centrality	Year	Keywords
194	0.03	2019	artificial intelligence	63	0.03	2019	online learning
188	0.05	2019	machine learning	62	0.15	2019	technology
132	0.03	2019	students	56	0.01	2019	model
84	0.03	2019	education	54	0.03	2019	higher education
81	0.03	2019	intelligent tutoring systems	53	0.05	2019	knowledge
81	0	2019	performance	51	0.09	2019	science
73	0.01	2019	learning analytics	47	0.01	2019	achievement
68	0.03	2019	natural language processing	45	0.06	2019	educational data mining

4.2 Keyword Network Clustering Analysis

As shown in Figure 5, 15 clustering results studied in the last five years of journals are presented. After performing keyword clustering, Slihouette S = 0.9063 (>0.7) indicates a good clustering result and Modularity Q = 0.763 (>0.3), which indicates a significant clustering structure. Table 4 demonstrates the information about the frequency of clustering keywords and clustering profile values for the top 10 WOS clusters.

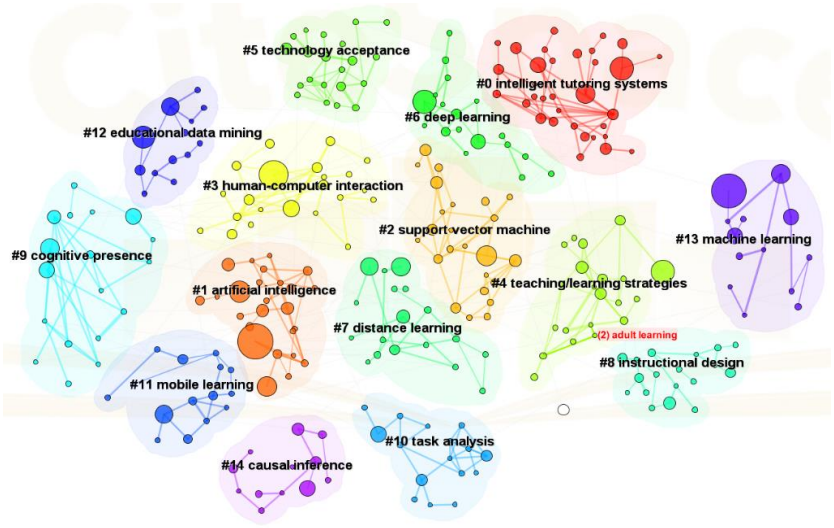

Figure 5. WOS Education AI Keyword Clustering (Partial)

The top 10 clustered keywords are, in order: intelligent instruction system, artificial intelligence, support vector machine, human-computer interaction, teaching/learning strategy, technology acceptance, deep learning, distance learning, instructional design, cognitive presence, task analysis, mobile learning, educational data mining, machine learning, causal inference. Among them, support vector machine is a new machine learning method based on statistical learning theory, which is mainly

applied in speech recognition, face detection and recognition, and text categorization (Wang, Li, & Yang, 2014). This study summarizes and categorizes the keyword clustering and combines with the existing research of previous researchers, and considers that there are two main themes focused on in the research results of educational artificial intelligence in foreign countries: the application case study of machine learning, and the research of teaching/learning methods focusing on human beings with technical support.

(1) Application case studies of machine teaching: including keywords such as intelligent guidance system, artificial intelligence, support vector machine, deep learning, machine learning. Since 2019 and beyond, relevant studies on machine teaching still mostly focus on practical applications of teaching (Zhang, Zhao, & Li, 2019). Machine learning is one of the many fields encompassed by artificial intelligence, which is used for predictive modeling, intelligent analysis, and assistive technology in the field of education (Salas-Pilco & Yang, 2022). Yung-Hsiang Hu and other scholars concluded that tutoring students with an intelligent tutoring system and tutoring by teachers did not have a significant difference in student achievement and the average class score was higher by using a control group experiment (Hu, Fu, & Yeh, 2023).

(2) Research on human teaching/learning styles with technical support: including instructional design, teaching/learning strategies, distance learning, mobile learning, technology acceptance, cognitive load, etc. Jones shows that current research is actively using various technologies such as educational data mining, machine learning, learning analytics, etc., to track, summarize, and analyze students' learning behaviors using a variety of educational models, so as to target teaching and improve the quality of teaching (Jones, 2019). At the same time, the exploration of ethical risks caused by the application of artificial intelligence has also become one of the directions of educational artificial intelligence research.

Table 4. Clustering Keywords for the Top 15 WOS Educational AIs

cluster number	Clustering Keywords	frequency	Clustered mean contour values	Average year of publication
0	intelligent tutoring systems	33	0.912	2020
1	artificial intelligence	25	0.913	2020
2	support vector machine	25	0.843	2020
3	human-computer interaction	22	0.904	2020
4	teaching/learning strategies	21	0.958	2020
5	technology acceptance	21	0.918	2022
6	deep learning	18	0.943	2020
7	distance learning	18	0.815	2020
8	instructional design	18	0.926	2021
9	cognitive presence	18	0.874	2020

4.3 Keywords Emergent Research Trends Frontier Analysis

Figure 6 shows the foreign keyword emergence graph, according to the emergence intensity in descending order, take the first ten keywords, they are recognition, text, formative assessment, individual difference, attitudes, task analysis, big data, self regulation, outcome, and learning performance.

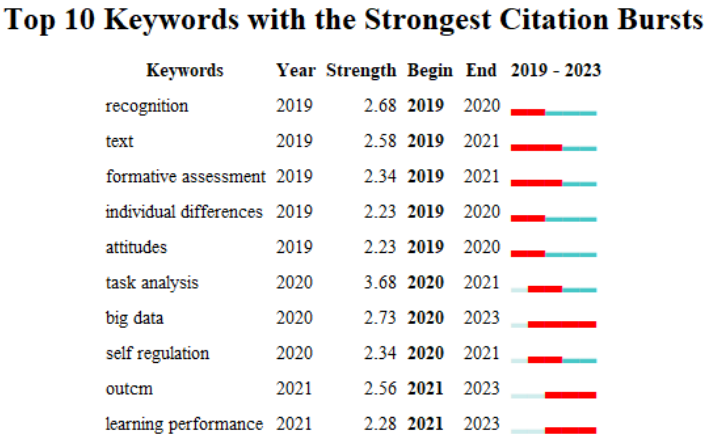

Figure 6. WOS Education AI Keyword Bursting Map

As can be seen from the figure, the keywords that emerge before 2020 are mostly the application of artificial intelligence in education and the concern for human development in the age of intelligence, such as face recognition, text analysis, and the study of individual differences, and the research trend after 2020 continues to evolve towards educational big data and learning performance. Educational big data brings great benefits to teachers, students, administrators, etc., and can be used in various aspects of faculty management, teaching innovation, research management, such as predicting student performance, employment alerts, teaching evaluations, and intelligent push (Bai, Zhang, Li, et al., 2021), demonstrating the important role of using analytics to help make decisions to improve the quality of teaching and learning. Meanwhile, scholars such as Kirsty Kitto (2023) have also proposed the use of causal inference to build a bridge between education and big data in response to the difficulty of translating the link between educational theory and big data.

5. Conclusions and Outlook of the Study

In this paper, we clearly and intuitively sort out the research hotspots, topics and trends of "Artificial Intelligence in Education" at home and abroad in the past five years by displaying a visual map, and draw the following conclusions:

(1) From the research level, it can be seen by comparing the domestic and foreign research on AI in education that the domestic research on AI in education is mostly from the macro level, such as AI applications, ethical risks, educational models, etc., mostly theoretical inquiry; while foreign countries

are mostly from the micro level, focusing on technological innovations and practical applications, and focusing on the development of teachers and students in the age of intelligence.

(2) From the research object, there are similarities between domestic and foreign research in recent years, not only focusing on the application of artificial intelligence in education, but also both focusing on human development. Domestic is mostly based on AI technology to promote students' personalized learning, focusing on teachers' professional development, talent cultivation and other issues; foreign is mostly focusing on students, and the focus on teachers is relatively weak.

(3) From the research frontier, both domestic and foreign countries are concerned about the application of cutting-edge technology of artificial intelligence, but the domestic research on the use of new technologies and methods in teaching is still relatively backward, such as the research on causal inference in the field of education, and the use of support vector machines in education in the field of machine learning, etc. are seldom embodied in the existing research.

With the arrival of the intelligent era, the development of artificial intelligence in the field of education is inevitable, our country in the future still need to continue to strengthen the use of technology for the promotion of human development on the development of teachers, focus on the development of teachers, student development, the better use of technology to teaching, learning, management, evaluation and other aspects, to strengthen the cultivation of talents, and truly realize the two-way empowerment of science and technology and education.

Fund Program

2024 Social Science Project of Huanggang City "Research on Influencing Factors of Middle School Teachers, Acceptance of AI Tools" (Project number: 2024095).

References

Bai, X., Zhang, F., Li, J., et al. Educational big data: Predictions, applications and challenges. *Big Data Research*, 2021, *26*, 100270.

Cao Peijie. The Triple Realm of Artificial Intelligence Education Reform. *Education Research*, 2020, *41*(02), 143-150.

Chen Lijun, Zeng Qunfeng, Cai Zhi. Comparative Analysis of the Impact of Artificial Intelligence on Skill Enhancement Research at Home and Abroad. *China Vocational and Technical Education*, *2023*(18), 5-14.

Chen Yue. *Principles and Applications of Citation Space Analysis: A Practical Guide to CiteSpace*. Science Press, 2014.

Cui Jingui, Ma Yingying. Research Progress and Prospect of Artificial Intelligence Education in China. *College Education Management*, 2023, *17*(06), 31-39.

Hou Jianhua, Hu Zhigang. Review and Prospect of CiteSpace Software Application Research. *Modern Intelligence*, 2013, *33*(04), 99-103.

Hu Xiaoyong, Sun Shuo, Yang Wenjie et al. Empowering High Quality Development of Education with Artificial Intelligence: Needs, Vision, and Path. *Modern Educational Technology*, 2022, *32*(01), 5-15.

Hu, Y. H., Fu, J. S., Yeh, H. C. Develop an early-warning system through robotic process automation: Are intelligent tutoring robots as effective as human teachers? *Interactive Learning Environments, 2023*, 1-14.

Huang Ronghuai, Wang Yunwu, Jiao Yanli. Educational Reform for the Intelligent Era: A Proposition on the Dual Empowerment of Technology and Education. *China Electronic Education, 2021*(07), 22-29.

Jones, K. M. L. Learning analytics and higher education: a proposed model for establishing informed consent mechanisms to promote student privacy and autonomy. *International Journal of Educational Technology in Higher Education*, 2019, *16*(1), 1-22.

Kitto, K., Hicks, B., Buckingham Shum, S. Using causal models to bridge the divide between big data and educational theory. *British Journal of Educational Technology*, 2023.

Li Jie, Mei Chen, Chao Mei. *CiteSpace: Technology Text Mining and Visualization*. Capital University of Economics and Business Press, 2016.

Li Zheng, Zhou Xiaoyong. Review and Future Prospects of Domestic and Foreign Language Education Technology Research in the Past 20 Years: Visualization Analysis Based on CiteSpace. *China Electronic Education*, *2018*(06), 91-96+122.

Liang Zheng, He Jiayu. Empowering Education with Artificial Intelligence: Application Status and Future Prospects. *People's Education*, *2023*(09), 21-26.

Salas-Pilco, S. Z., Yang, Y. Artificial intelligence applications in Latin American higher education: a systematic review. *International Journal of Educational Technology in Higher Education*, 2022, *19*(1), 1-20.

Wang Guohua, Yu Shuyu, Huang Huifang et al. Visual Analysis of Distance Education Research in China: Core Literature, Hotspots, Frontiers, and Trends. *Distance Education Journal*, 2015, *33*(01), 57-65.

Wang Haiyan, Li Jianhui, Yang Fenglei. Review of Support Vector Machine Theory and Algorithm Research. *Computer Application Research*, 2014, *31*(05), 1281-1286.

Yan Zhiming, Tang Xiaxia, Qin Xuan et al. "The Connotation, Key Technologies, and Application Trends of Educational Artificial Intelligence (EAI) - Analysis of the Reports" Preparing for the Future of Artificial Intelligence and "National Artificial Intelligence Research and Development Strategic Plan" in the United States. *Distance Education Journal*, 2017, 35(01), 26-35.

Yuan Lei, Zhang Shuxin, Lei Min et al. Technology Empowering High Quality Development of Education: Frontiers of Artificial Intelligence, Blockchain, and Robotics Applications. *Open Education Research*, 2021, *27*(04), 4-16.

Zhang Rongfei, Zhao Leilei, Li Yuehong et al. Analysis of Research Themes and Trends in Artificial Intelligence in Education Abroad: Visualization Analysis Based on Web of Science Literature Keywords. *Modern Educational Technology*, 2019, *29*(12), 5-12.

Zhu Zhiting, Hu Jiao. Essence Analysis and Research Prospects of Digital Transformation in Education. *China Electronic Education*, *2022*(04), 1-8+25.

Zhu Zhiting, Lu Linmeng, Wang Xinyi et al. Development of Smart Education Theory and Practice in China: A Decade Review and Future Prospects. *China Distance Education*, 2023, *43*(12), 21-33+45.