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Knowledge Mapping for the Study of Artificial Intelligence in Education Research: Literature Reviews

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ABSTRACT. This study aims to provide a systematic and complete knowledge map for researchers working in the field of research on the application of artificial intelligence in education. In addition, it is designed to help researchers quickly understand author collaboration characteristics, institutional collaboration characteristics, trending research topics, evolutionary trends, and research frontiers of scholars from a library informatics perspective. In this study, a bibliometric approach was used to quantitatively analyze the retrieved literature with the help of the bibliometric analysis software CiteSpace. The analysis results are presented in tables and visual images in this paper. The results of this study indicate that collaborative relationships among scholars need to be improved and collaborative research relationships among research institutions are more fragmented. This study also points out the shortcomings of this study: Chinese educational researchers and practitioners still have a relatively vague understanding of some fundamental issues in the process of integration and development of AI and education. Therefore, this paper uses quantitative research methods such as bibliometrics

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and visualization pictures to systematically and intuitively reveal the research progress and trends on the application of artificial intelligence in education based on the published literature and to provide a reference for further research on this topic in the future.

KEYWORDS: Artificial Intelligence; Education

1. INTRODUCTION

Artificial intelligence is the science and engineering of making seeded machines that exhibit human behavioral intelligence characteristics, including reasoning, learning, goal-seeking, problem-solving, and adaptability (Monostori, 2014).Artificial intelligence, as a vital technological force for social development, has rapidly penetrated all walks of life and become a new driving force and trend for the development of various industries.In this situation, it has become a significant challenge for governments worldwide to adapt education to the needs of the intelligent era and to use innovative technologies to promote changes in teaching models and the cultivation of creative talents.The U.S. 2016 release, Preparing for the Future of Artificial Intelligence, refers to implementing AI education and expanding AI and data science curricula into developing the talent needed for AI to drive economic development (White House, 2016).The Development Plan for a New Generation of Artificial Intelligence promulgated by the Chinese State Council in July 2017 proposes to develop intelligent education, use innovative technology to accelerate the reform of talent training models as well as teaching methods, build a new education system that includes intellectual learning and interactive learning, and promote the application of artificial intelligence in teaching, management, and resource construction (Chinese State Council, 2017a).In the same year, the 13th Five-Year Plan for National Education Development promulgated by the State Council of China also proposed to "explore new models of future education and teaching by making comprehensive use of technologies such as the Internet, big data, artificial intelligence, and virtual reality" (Chinese State Council, 2017b).As can be seen, the use of AI technology to promote change and innovation in education systems has attracted a great deal of attention from countries around the world.

Although China's education reform has made remarkable progress, there are still some outstanding problems, such as unbalanced education development, an imperfect cultivation model of innovative talents, and an unreasonable allocation of quality education resources. With the advent of the intelligent era, artificial intelligence will become a "powerful tool" to crack these educational problems, playing an essential role in innovating education and teaching models, optimizing talent training programs, developing students' professional skills, and building a lifelong learning system to promote the change and development of education in the future.

In recent years, domestic experts and scholars in the field of education have focused on the connotation and critical technologies of educational AI (Leun et al., 2017), the connotation and target orientation of intelligent education (Zhang Jinbao et al., 2018), the promotion of AI for blended teaching (Dai Yonghui et al., 2018) and the innovative educational applications of deep learning and machine learning (Liu Yong et al., 2017; Yu Minghua et al., 2017), Etc. A preliminary discussion was conducted.However, educational researchers and practitioners still have a relatively vague understanding of some fundamental issues in the integration and development of AI and education, such as the technical framework of AI in education, application models, and development challenges.

Based on this, this study uses Citespace software to visualize and analyze the literature related to the research topic of artificial intelligence in education so that the readers can understand the current situation, research hotspots, and research trends of this research topic of artificial intelligence in education in China more clearly and intuitively, and thus provide references for further in-depth research on the research topic of artificial intelligence in education.

2. LITERATURE REVIEW

Citespace is a Java-based information visualization software developed by Professor Chaomei Chen of Drexel University, USA. It can extract scientific literature, generate corresponding visual atlases, and interpret them

to understand the knowledge base, research hotspots, disciplinary frontiers, and new trends in related fields (Chen Chaomei, 2006). CiteSpace requires JRE 1. 4. 2 or higher as the runtime environment for the software authoring platform. Although CiteSpace can access many web services and other information through PubMed, etc., the Internet is unnecessary for CiteSpace to run. The data file format input to CiteSpace is the data format output by ISI. Unlike other similar information visualization software, the CiteSpace software itself comes with a data converter, which can directly convert the data format downloaded from the Internet without converting the downloaded raw literature data to the correlation matrix, which can eliminate the complex steps and processing of correlation matrix conversion, which is one of the advantages of CiteSpace software (Chen C, 2004).Before starting data processing with CiteSpace, the literature data files must be placed in the same folder. In addition, the name of each data file must begin with "download" and have ." txt" as a suffix. Before creating a new project using CiteSpace, two paths need to be specified, one for the literature data store and one for the project store. The project storage path allows researchers to find saved images and output files while CiteSpace is running, and the setup process is done from the main CiteSpace interface.

CiteSpace has the following essential features. (1) The raw data does not need to be converted into the format of the matrix, and the raw data format of databases such as WOS and CNKI can be directly imported into CiteSpace for calculation and plotting; (2) For the same data sample, multiple plots can be performed to show the evolutionary characteristics of the data from different perspectives. (3) The software clearly shows the change of literature data over time by marking nodes and connecting lines with different colors; (4) The color of nodes is represented chronologically, clearly showing the citation of different periods; (5) The color of connecting lines represents the earliest time when the co-citation frequency of that connecting line reaches the selected threshold.

CiteSpace has four essential functions: (1) Identify critical paths in the evolution of subject areas through citation network analysis. (2) Identify crucial literature for the evolution of disciplinary fields. (3) Analyzing the potential dynamic mechanisms of disciplinary evolution. (4) Predicting disciplinary frontiers.

CiteSpace software is used to detect and analyze temporal trends in disciplinary research frontiers and their relationship to the knowledge base and to discover internal connections between different research frontiers. By visually analyzing the information in the literature on the subject area, researchers can visually discover the evolutionary path of the subject frontier and the classical primary literature of the subject area.

CiteSpace software uses the cosine algorithm to calculate the strength of collaboration between researchers or institutions, and the power of connection between nodes represents the strength of association between researchers or institutions, which is calculated by the cosine distance of the angle between nodes (Chunlai Yan, Hongxia Li & Ruihui Pu, 2022). Equation (1) is as follows.

$$Cosine\,(x,y)=\frac{XY}{[X][Y]}=Cosine\,(c_{ij},s_i,s_j)\frac{C_{ij}}{\sqrt{S_iS_j}}$$

Where c_{ij} represents the number of papers published by co-authors (author i and author j), S_i and S_j represent the number of documents published by author i and author j, respectively, and the value of collaboration intensity ranges from 0 to 1.

The main principles and methods of using Citespace are as follows:

Divide and conquer principle: The idea of the divide and conquer strategy is to divide a significant problem that is difficult to solve directly into several smaller-scale identical problems and solve them separately, dividing and conquering them. The basic idea of divide and conquer is to decompose a problem of size n into k smaller subproblems that are independent of each other and identical to the original problem. The solution for each part is found, and then each part is combined into a solution for the whole problem.

Success breeds the success principle: if a paper is cited in more articles, the greater the probability of encountering it when reading the literature and, therefore, the greater the probability of citing it in an article. Barabasi and Albert (1999) showed that many real-world complex networks are not regular random networks but belong to scale-free networks and made several studies on such a class of networks' Some studies on the number of features point to two fundamental properties that determine the scale-free properties of networks such as the Internet, the World Wide

Web, and collaborative research networks of scientists: node growth and preferential connectivity.

Minimum spanning tree algorithm. Suppose G = (V, E) is an undirected connected weighted graph, and if the subgraph G' of G is a tree containing all the vertices of G, then G' is called the spanning tree of G. The sum of the weights of the edges of the spanning tree is called the consumption of the spanning tree. Among all the spanning trees of G, the spanning tree with the minor consumption is called the minimal spanning tree of G. In modern mathematical graph theory, Prim's algorithm and Kruskal's algorithm can be applied and implemented by computer programming statements.

Expectation maximization algorithm. The maximum expectation clustering method (EM clustering for short) is a basic algorithm for large likelihood estimation in statistics, i.e., the maximum likelihood estimation of parameters in distribution with hidden state variables. The algorithm is mainly applied to estimate the missing variable X from the available information Y when the data is incomplete. The E step takes the conditional expectation, and the M step takes the maximum value. This iterative optimization method is known as the EM method. Clustering is performed by distance characteristics of nodes but by specific parameters, such as year of publication, authorship, node centrality, half-life, number of citations, etc. The criteria for clustering are determined by statistical analysis using the maximum likelihood estimation of the algorithm. Clusters of nodes shown on the graph as different colors, i.e., clusters of nodes of the same color, form the same cluster. Further statistical analysis of the clusters leads to the expected results.

Word frequency analysis method. By counting the frequency of core words such as keywords, subject words, and chapter words that appear in specific academic literature, the research hotspots, knowledge structure, and development trend of that academic field can be revealed (Li Yan, 2011). Counting the frequency of subject terms appearing in a literature set can form a clustering network of these word pair associations. The proximity between nodes within the network can reflect the affinity of the subject content (Liu I, Huang Chuanhui, 2010).

Citation analysis method. The citation and cited phenomena of scientific and technical journals, papers, authors, and other analysis objects are analyzed to reveal their quantitative characteristics and internal laws.

CiteSpace generates maps with richer colors and better appearance.In addition, we can view the articles covered by the nodes, the cluster's size and content, and the cluster's average year from the visual image.Therefore, we decided to use CiteSpace to analyze the data from this study.This study allows us to derive visual images, obtain partnerships between authors and research institutions, and identify research trends in the research topic of Artificial Intelligence in Education. The subject of this study is the application of artificial intelligence in education, which belongs to the subject of education, and CNKI collected all data on this subject.With the help of CNKI data sources, this study conducted preliminary research and obtained 527 literature records using advanced search tools with the search terms artificial intelligence and education. The authors imported these 527 documents into cite space software, automatically checked the weights, eliminated non-research documents and de-weighted them, and finally identified 518 documents. The authors used word frequency analysis and citation analysis to conduct the analysis.

3. RESEARCH TRENDS

3.1 Analysis of the results of a survey of Chinese researchers

Analyzing the distribution of authors is a prerequisite to deeply grasping the research field and scientific research dynamics of a particular discipline. The study of authors with in-depth insights and scientific achievements in the related fields can effectively grasp the development process of scientific research activities in this field, which is of positive significance to the analysis of the current situation, summary, refinement, and future research of the research topic.After the data were imported into Citespace V, the node was set to Author, in 2003–2020, with a time cut of 1 year. Set Selection Criteria (top = 50, selecting the top 50 strata for each year) to get the visualization plot (as shown in Figure 1). Each circular node in the figure represents a different author of the posting; the more significant the corresponding font of the author, the more the posting volume, and the connecting line between the nodes represents the cooperation relationship between the authors, the thicker

the degree of connection, the more the cooperation posting. In the figure Largest C C is 5 (2%), indicating that the largest group of AI in education research partnership has five people, respectively, Qinhua Zheng as the primary researcher and Xinfeng Gao, Li Chen, Lei Xie, and Yujuan Guo as a supplementary collaborative research team, which accounts for only 2% of the total number of researchers.

3.2 Distribution of Chinese Institutions for Research on the Application of Artificial Intelligence in Education

The node type was changed to the institution, and the software was run to obtain the visual mapping of research institutions on the application of AI in education, as shown in Figure 2. The top 10 institutions in terms of the number

Figure 1. Visualization of authors of research on the application of artificial intelligence in education.

Figure 2. Visual mapping of research institutions on the application of artificial intelligence in education.

of publications were selected to draw Table 1. According to Figure 2, it can be seen that the College of Education of Shaanxi Normal University and the College of Education Technology of Beijing Normal University, and the College of Education Science of Xinjiang Normal University are tied for first place in terms of the number of articles, with four articles; the Cunjin College of Guangdong Ocean University, the Department of Education of Beijing Normal University, the Department of Education Technology of the College of Education of Peking University, the College of Education of Tianjin University, and the Liaoning Construction Vocational College are tied for the fourth place in terms of the number of articles, with three articles; the Party School of the Communist Party of China Beijing Materials Co. and the College of Teacher Education of Zhaoqing College are tied for the ninth place in terms of the number of articles, with two articles.This suggests that these research institutions have not focused much on how AI can be applied in education and have not studied it in depth. However, upon investigation, it was found that researchers in these institutions have researched the application of AI in various fields. However, there is no specific research focusing on the application of AI to a particular field.The fragmentation of each node in the whole network mapping is more serious, which indicates that the research among institutions is still relatively independent. The cooperation is not close enough and needs to be strengthened. The nature of the institutions shows that most institutions conducting and publishing-related research are universities, indicating that the leading positions of AI in education application research are in universities, and they are credited with the rapid development of AI in education application research.

3.3 Hot spot analysis of Chinese research on the application of artificial intelligence in education

Keywords are a high-level summary of the research topic and content of the literature. Proper keyword analysis can tell the literature's actual research content, and measuring the number of keywords can determine the hot spots of disciplines, institutions, and research knowledge base in a specific period. This research set the node as Keywords, set the node threshold as Top N = 30, selected "pathfinder" to crop, and ran the software to obtain the knowledge map of AI in education application research hotspots (Figure 3). The nodes in the figure represent the keywords of the retrieved documents, the size of the circle to which the keywords belong represents their frequency of occurrence, and the connecting lines between the nodes represent the co-occurrence relationship between the keywords. The centrality is a measure of the size of the connectivity in the knowledge graph network, and a purple color at the edge of the circle indicates that the centrality value of the node is greater than or equal to 0.1.

According to the keyword co-occurrence mapping and partial keyword table of AI in education, it can be seen that the frequency and

Table 1. Top 10 research institutions in terms of the number of articles published on the application of artificial intelligence in education.

Serial number	Count	Year	Institution
1	4	2019	College of Education, Shaanxi Normal University
2	4	2006	College of Educational Technology, Beijing Normal University
3	4	2018	College of Education Science, Xinjiang Normal University
4	3	2019	Cunjin College of Guangdong Ocean University
5	3	2018	Department of Education, Beijing Normal University
6	3	2010	Department of Educational Technology, College of Education, Peking University
7	3	2018	College of Education, Tianjin University
8	3	2018	Liaoning Construction Vocational College
9	2	2019	Party School of Communist Party of Beijing Materials Co.
10	2	2019	School of Teacher Education, Zhaoqing College

Figure 3. Keyword co-occurrence mapping of research on the application of artificial intelligence in education.

Table 2. Key words of research on the application of artificial intelligence in education.

Serial number	Count	Centrality	Key word
1	124	0.57	Artificial Intelligence
2	108	0.62	Artificial Intelligence Education
3	17	0.1	Education
4	13	0.03	Artificial Intelligence Technology
5	12	0.09	Smart Education
6	11	0.05	Education Applications
7	9	0.08	Deep Learning
8	8	0.06	Primary and Secondary Schools
9	7	0.02	Education Informatization
10	5	0	Education Technology
11	5	0.01	Artificial Intelligence Curriculum
12	5	0.04	Information Technology
13	4	0.03	Big Data
14	4	0.03	Ministry of Education
15	4	0.02	Human-Machine Collaboration
16	4	0	Information Literacy
17	4	0.02	Talent Cultivation
18	4	0.01	Programming Education
19	3	0.02	Creativity Education
20	3	0.03	Learners
21	3	0	grace
22	3	0.03	Intelligent Age
23	3	0.02	High School
24	3	0.06	Information Technology Course
25	3	0	Artificial Intelligence Era
26	3	0.01	New Engineering
27	3	0	Artificial Intelligence+
28	3	0.02	Teaching Artificial Intelligence
29	2	0.01	IT
30	2	0	Education Artificial Intelligence

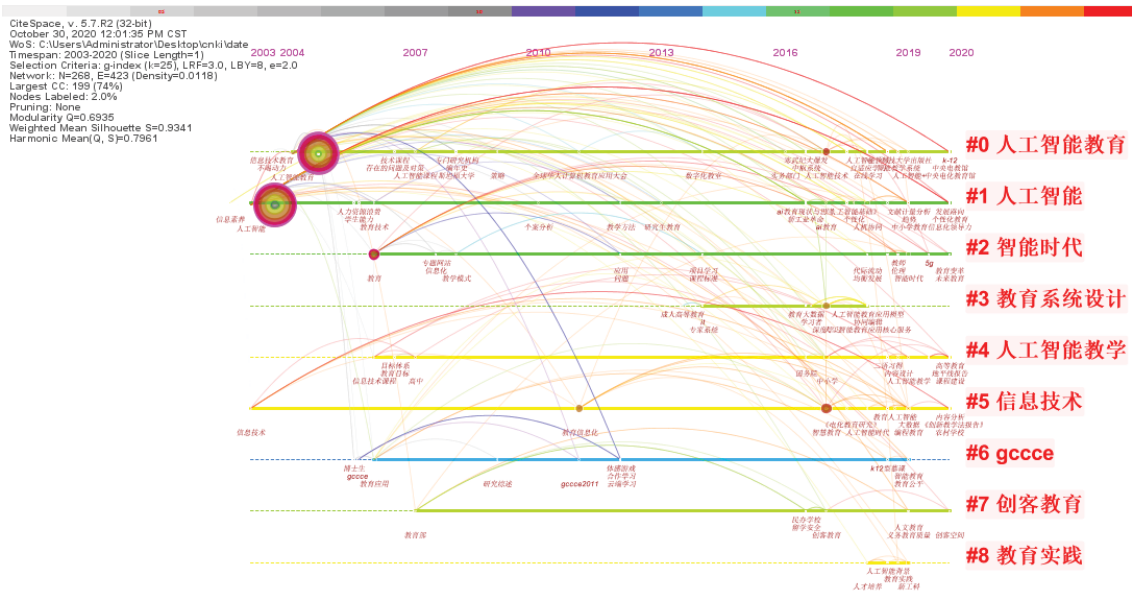

Figure 4. Timeline of research hotspots on the application of artificial intelligence in education.

centrality of "AI," "AI education," and "education" are in the top position. The corresponding node area is large, which indicates the accuracy of data retrieval and topic matching, and the series of keywords are consistent and comprehensive in the domestic concept.As shown in Figure 3, "smart education," "educational applications," "deep learning," "primary and secondary schools," and "education informatization" are the main research hotspots.

3.4 Keyword evolution analysis of research on the application of artificial intelligence in education

In addition to static analysis of the distribution of research hotspots of AI in education, it is also necessary to pay attention to the time zone changes of hotspots to discover the future development direction more effectively. We set the time segmentation as 2003–2020, select the node Keywords, set the node threshold as Top N = 20, and output the result as "Time Zone" to form the time zone distribution of AI in education research hotspots (Figure 4).).

The time-zone distribution chart of research on the application of artificial intelligence in education consists of a series of keywords in the corresponding time intervals, and the keywords corresponding to each time interval indicate the hot issues of research on the application of artificial intelligence in education in this time interval.From Figure 4, it can be seen that the research on the application of AI in education from 2003 to 2020 is rich, and the whole is developing in depth. 2003–2020, with the increasing improvement of intelligent technology, the development of 5G, Wap, cloud computing, smartphones, mobile Internet, and other technologies tend to mature, and user needs are more extensive, profound research on AI education, artificial intelligence, and the intelligent era was conducted in this stage; in 2003, scholars mainly profiled information literacy and AI terminals; in 2004, the main direction of research was information technology education, including AI education, etc.; in 2006, scholars profiled the technology curriculum and the problems that existed.

4. CONCLUTION

The emergence of artificial intelligence technology has pointed out the direction for the intellectual development of computer network technology. Applying this technology to computer network technology is conducive to enhancing the technical level of computers and better-providing quality services for social and economic development.

Through the visual analysis of this study, the author believes that research can be conducted in the following five areas.

Increase the research and development of educational AI products and improve the quality of technical services: The research and development of educational AI products and

the improvement of technical service quality require efforts from many aspects.First, we should strengthen the cooperation between experts in the field of education, artificial intelligence experts, and enterprise personnel to understand the current realistic needs of education, find the fit between artificial intelligence and education, and promote the development and application of intelligent products in education.Second, the functional modules of educational AI products should be continuously expanded to effectively meet students' personalized learning needs and teachers' teaching requirements at different stages. Currently, the Chinese government actively advocates the introduction of AI-related courses in primary and secondary schools, so it can develop educational AI products that go with them, such as programming-based teaching tools and software, as a way to assist education and teaching and optimize students' learning effects.Third, to establish a complete education AI product safety supervision and evaluation system, standardize industry standards, and increase market supervision and monitoring efforts to ensure that enterprises provide safe, high-quality products and services for the development of education AI.

Broaden the application space of artificial intelligence in education, multi-disciplinary cross-collaboration to help the development of education innovation: dig deeper into the application value of artificial intelligence in education, expand the application space so that it can better provide services for education and teaching.Artificial intelligence technology can break the barriers to education and effectively integrate formal and informal learning. Therefore, it is recommended that the Chinese government establish an AI education service platform to gather global high-quality education resources and precisely push learning resources suitable for learners' development according to their needs. Establishing an AI education management platform in China to track and record learning process data and conduct deep mining and learning analysis to comprehensively understand learners' interests and real-life needs can help to realize personalized education and lifelong learning.

Build a harmonious symbiosis "human-machine combination" new ecology, enhance the sense of trust in artificial intelligence in education: the integration of artificial intelligence and education is an important trend in the intelligence era.Educational AI will replace the repetitive work of teachers and reduce their pressure and burden to a certain extent, allowing teachers to spend more time optimizing the instructional design to facilitate students' personalized learning. However, education involves cultivating students' moral qualities, values, and emotional attitudes that cannot be replaced by artificial intelligence and still needs to be done by teachers.Therefore, "human-machine integration" will become the mainstream trend of future education development. Specifically, mechanical and repetitive tasks will be completed by machines, such as replacing teachers to correct homework, organizing and collecting learning materials, arranging exams, etc. Teachers will focus more on emotional interaction with students, shaping students' personalities, cultivating moral qualities, and improving higher-order thinking skills.In addition, human-machine trust is a critical factor in developing educational AI. Establishing a long-term human-machine trust mechanism is a prerequisite for building a harmonious and symbiotic "human-machine combination" new ecology. Therefore, it is necessary to accelerate the improvement of the AI governance system, develop and embed ethical standards, create a more powerful, safe, and trustworthy educational AI application system, and promote the peaceful development of AI and education integration.

Strengthen the "government, enterprise, academia and research" multi-party cooperation, collaborate to promote the rapid development of artificial intelligence in education: the integration of artificial intelligence and education is a long-term and arduous task, only "government, enterprise, academia and research" multi-party cooperation to promote collaborative, will achieve significant results.First of all, the government should attach great importance to the development of educational AI, establish a sound system to guarantee the system, and continue to increase the financial support for educational AI to protect the innovation of intelligent technology.Secondly, enterprises should increase the design and development of educational AI products, expand product supply, improve service quality, and cooperate extensively with schools and research institutes to broaden the development channels of enterprises.Again, schools should actively explore the education and teaching mode supported by AI technology, offer AI-related courses, and focus on cultivating students' data science literacy and computational thinking skills to

meet the development needs of the future intelligent era and continuously deliver talents for enterprises and research institutions. Finally, research institutes should focus on the frontier of AI development, widely conduct theoretical research on AI educational applications, and build a new generation of educational AI theoretical systems. Through continuous technical breakthroughs and product innovation, solve the technical problems faced in the development of educational AI and provide technical support for developing enterprise products.

Establishing educational AI demonstration sites and exploring the application model of educational AI: Based on the principle of "piloting first, leading by points and gradually promoting," we will select areas and schools with good informationization conditions to establish educational AI demonstration sites and explore the application model of educational AI, and gradually promote it to the whole country.Specifically, the demonstration site hired industry or university AI experts as consultants to provide regular guidance on the construction of the demonstration site and worked to build a team of information technology personnel, including AI teachers. In addition, artificial intelligence business training is provided to administrators and teachers in pilot district schools to strengthen education administrators' understanding of AI educational applications and to enhance teachers' ability to apply AI technologies. Finally, an effective incentive and guarantee system is developed to encourage teachers and administrators to innovate the application of AI technology, innovate the education and teaching model, and improve teaching standards.

In the era of big data, the integration of artificial intelligence and computer network technology is deepening. Based on the characteristics of artificial intelligence technology, the application of artificial intelligence in computer network technology in the era of big data can be explored and analyzed in depth. In addition, AI technology will also complement blockchain, the Internet of Things, and cloud computing technology. Therefore, the future of artificial intelligence education is promising, and there will be a sharp shortage of artificial intelligence talents. Even artificial intelligence has been able to be applied in early childhood education; these are opportunities and challenges for the development of artificial intelligence education.

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