Research hotspots and development trends of smart education in the past seven years Based on visual knowledge graph analysis by Citespace

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Abstract: Education is a new realm of educational informatization whose purpose is to create a smart learning context to meet the new needs of the current development of teaching and learning changes. The current smart education is a new ecology of education, which is constructed based on economic globalization, technological change and the big knowledge explosion. This study uses bibliometric method, the data are all core journal literature in China Knowledge Network database, describing high-frequency keywords and emerging emergent words in the field of wisdom education with the help of CiteSpace software, and mapping multiple dimensions such as the number of journal academic papers, popular academic research institutions and types of academic journals about The scientific knowledge map of the literature on "smart education" was drawn from various dimensions, including the number of journal academic papers, popular academic research institutions and types of academic journals. Four features of the current development of wisdom education were finally derived: the gradual deepening of the wisdom education research system, the gradual shift of research subjects from conceptual design to application practice, the specialization of groups and scholarly representation of research findings, and the in-depth development of technology products by enterprises. On the whole, China's wisdom education research is gradually undergoing a transformation from the initial theoretical exploration stage to the practical application process. With the support of artificial intelligence and big data technologies, teaching organization and teaching evaluation system on a large scale, and personalized smart learning will become the main form of learning in the future.

Keywords: smart education; education informatization; knowledge mapping.

1 Introduction

At present, the rapid development of emerging information technology such as artificial intelligence and 5G is driving the rapid transformation of traditional education to the new era of information technology-enabled smart education. Smart Education[1] is advancing from concept and model to landing and practice, and gradually moving from the initial sporadic attempts to the scale innovation stage, which is rapidly driving a new round of innovation in existing school education and teaching. In short, the development and innovation of smart education is taking place in many ways, including the form of school construction, the way classrooms are taught, the country's education provision model and the new context of online education. Smart education has been given the heavy responsibility of reshaping the education

ITEI 2022, December 23-25, Harbin, People's Republic of China

DOI 10.4108/eai.23-12-2022.2329113

ecology, and the current smart education is essentially a new education ecology based on emerging technologies such as artificial intelligence.[2] . Smart education dedicates to creating smart curriculum and knowledge linkage contexts, transforming self-organized teaching and building a new digital education system, which is provided by the state, localities and schools in collaboration. Therefore, it is of great academic research value and practical guidance to systematically sort out the overall status of China's smart education research development in recent years. Despite the fruitful research results, the current research has not yet formed a standardized and unified understanding in terms of the overall origin, concept, theory and practice model, both domestically and abroad, which urgently requires a systematic analysis of the research themes, research frontiers and key hot issues of wisdom education in different periods. This study is based on the scientific analysis visualization software (CiteSpace) developed by Dr. Chaomei Chen's team, and through its knowledge mapping and econometric analysis functions.[4] This study is based on the scientific analysis visualization software (CiteSpace) developed by Dr. Chaomei Chen's team, and through its knowledge mapping and econometric analysis functions, we systematically analyze the relevant domestic and international literature in the past seven years with "smart education" as the theme, which can effectively help people interpret and foresee the research field of smart education in depth, and then grasp the latest development of domestic research on smart education and the future development trend, and provide some reference for the research and development of smart education in China. This will provide some reference for the research and development of the field of smart education in China.

2 Data and methods

2.1 Data source

Because of the large number of journals included in CNKI and the large gap between journals, this study selected "core journals + CSSCI" as the data source, and the key words were "smart education", "smart teaching", "smart learning" and "smart classroom". The key words are "smart education", "smart teaching", "smart learning" and "smart classroom", and a total of 1083 papers on related topics were retrieved (the search period is from January 2015 to December 2021), and Figure 1 shows the annual number of publications from 2015 to the present. Figure 1 shows the number of publications from 2015 to the present. The figure shows that the number of literature in the field of smart education has gone through three stages of slow growth-stable increase and rapid growth, and has shown an upward trend in the past seven years, in which the research before 2017 showed a slow growth trend and entered a popular research period since 2018, and the number of research literature continued to grow and reached the peaking in 2020, followed by an upward trend despite signs of slight fluctuations in 2021. This is partly because the national firm support for the development of education informatization as a motivating factor has strongly promoted the development of smart education; on the other hand, it is also because the rapid economic development and the development of information technology in recent years have provided good technical support for the implementation of smart education.

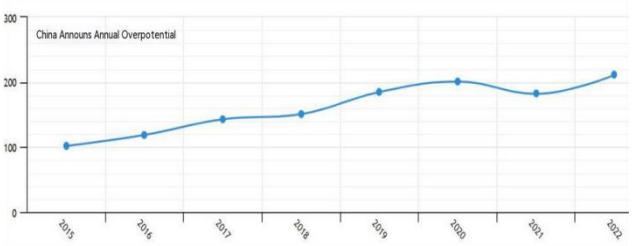

Figure 1 Smart education issuance volume (2015-2021)

2.2 Research methodology

There is no lack of inquiry into the hotspots in the field of wisdom education research in previous research results, however, with the development process of increasingly improved information technology and increasingly accurate bibliography, previous research based on summarizing and summarizing the literature is more subjective, so this study attempts to use bibliometric methods for quantitative analysis, and selects the Java application-based, developed by Professor Chaomei Chen's team, the CiteSpace software, developed by Prof. Chaomei Chen's team, was selected as an analysis tool to present the knowledge base in the field of smart education through scientific knowledge mapping. Through data exploration, information analysis, scientific measurement and graphical drawing, CiteSpace software is used to describe and count the cited and cited literature in the field of wisdom education, depict the research concentration areas of wisdom education, and then analyze the frontier hotspots, development paths and research topics in the field of wisdom education. Specifically, it includes the following aspects: first, the analysis of co-citation and coupling network. The co-citation relationship refers to the frequent occurrence of two or more keywords in the third cited literature (co-citation); while the coupling relationship refers to the quantitative analysis of the knowledge exchange phenomenon, i.e., two papers co-cite the third paper (coupling), at which the coupling strength is 1, and the coupling strength is proportional to the number of co-cited literature.[5] . Co-citation and coupling network analysis focuses on clustering noun terms from the keywords of cited literature, which in turn provides a clear picture of the research hotspots in the field of smart education. At the same time, the evolution of the research field can also be clearly seen through the timeline view, thus forming a more in-depth knowledge and understanding; second, by analyzing the cooperation network between research institutions and researchers, we can explore the dynamic network characteristics attributes of the cooperation between research institutions and core authors in the past seven years, which can reveal the research hotspots and potential cooperation opportunities in the field, so that we can better promote the research cooperation in the field of wisdom education; third, the theme or Keyword co-occurrence network analysis. Keywords are the essence of the condensation of the literature theme, by visualizing the co-occurrence of keywords with the time zone view, the theme analysis of this academic field can be formed quickly, and the hot spots and development frontiers of the research field can be understood with the least time and effort.

3 Data results

3.1 Co-citation and coupling network analysis

3.1.1 Keyword co-citation and clustering analysis

When researchers collectively focus on one or several issues during a certain period of time, then the frequency of the corresponding keywords increases, which also constitutes a research hotspot for that topic. As shown in Table 1, the keywords with high frequency in the field of smart education research in China are "smart classroom", "intelligent teaching space ", "elementary education", "teaching decision" and "educational modernization ". This reflects the focus and change in the development and advancement of the field of smart education.

Freq	Burst	Degree	Centrality	Σ	PageRank	Keyword
91		6	0. 00	1. 00	0. 00	smart classroom
49		5	0. 00	1. 00	0. 00	wisdom classroom
18		5	0. 00	1. 00	0. 00	intelligent education
9		7	0. 00	1. 00	0. 00	intelligent classroom
8		3	0. 00	1. 00	0. 00	smart learning space
6		1	0. 00	1. 00	0. 00	elementary education
4		1	0. 00	1. 00	0. 00	Teaching decision-making
4		4	0. 00	1. 00	0. 00	Lifelong learning
3		1	0. 00	1. 00	0. 00	blended learning
2		1	0. 00	1. 00	0. 00	educational modernization
2		3	0. 00	1. 00	0. 00	intelligent attendance
2		3	0. 00	1. 00	0. 00	knowledge tracing
2		2	0. 00	1. 00	0. 00	Immersion learning
2		2	0. 00	1. 00	0. 00	innovate

Figure 2 Co-citation of keywords

CiteSpace's keyword clustering analysis function can clearly map out the research hotspots and development trends in the field by presenting topic relevance. In the knowledge graph, keyword nodes are represented by circles, and the more frequently the topic appears, the larger the area occupied by the corresponding circle. The period of the topic is indicated by the color and thickness of the node, i.e., the thicker the inner circle of the circle, the higher the frequency of keywords in the year span corresponding to that color[6] . The keyword clustering map in the field of intelligent education was obtained by using the path recognition algorithm to cut and link the titles, abstracts, author information and keywords as the sources of clustering words (as shown in Figure 2). intelligent classroom" is the core of the research field of smart education, with the highest centrality, which can explain the basic role and important position of intelligent classroom; in the research field of smart teaching, "intelligent classroom" appears in the first place, followed by "smart teaching", "deep learning" and "big data", etc. Smart education can help reduce the cognitive load of students, meets the requirements of today's innovation era, and helps implement the "double reduction policy" while developing learners' ability to think deeply and learn independently. With the rapid development of education information technology, schools, training institutions, etc. began to introduce sensing technology, artificial intelligence technology and rich media technology and other high-tech to improve the teaching and learning environment, to create a smart classroom with intelligence, and now domestic educators and research scholars have also made a lot of relevant application research based on smart classrooms, how to build an effective smart How

to build an effective intelligent teaching model has always been a subject worthy of in-depth systematic research.

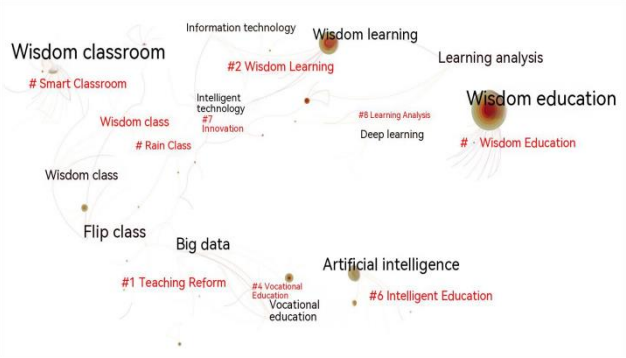

Figure 3 Clustering view of smart education keywords

3.1.2 Keyword emergent analysis

Mutation words refer to words that appear with high density in a short period of time, and their frequency changes can reflect the frontier and trend of the research field. According to the analysis of CiteSpace, the emerging themes of smart education and the corresponding prominence and citation history curves have been very clear, as shown in Figure 4(left). "smart learning", "Internet accelerated speed" and "maker education" are the hot spots of smart education research. Among them, "smart learning" was mainly reflected in 2015~2017, "Internet+" in 2015~2016 and "maker education" in 2015~2016, The overall study shows that the development of this theme is on the rise year by year. To a certain extent, this indicates that the current frontier of domestic wisdom education research is mainly reflected in the fields of wisdom learning, Internet+, creator education, and wisdom campus construction and operation and maintenance.

In order to clearly see the research focus of different time periods in the field of smart education, CiteSpace was used to draw a keyword co-occurrence timeline graph to visualize the evolution of the research focus from the dimension of time, as shown in Figure 4. At this time, the keyword (Keyword) is set as the node type, and the network cropping method still applies Pathfinder, Pruning sliced networks and Pruning the merged networks to precisely crop the collected data, followed by the option of Timeline View to make the different clusters under The keyword nodes are orderly distributed on the horizontal line of the corresponding class cluster, showing the state of the keywords contained in the class cluster evolving and developing with the year, presenting the results in Fig.4(right). From the figure, we can see that since 2015, there have been several keywords such as smart classroom, smart classroom, Internet+ and big data, and the relationship between the keywords is also very close, and the research in the field of smart education has a certain degree of heat. At the same time, it is also found that in recent years, hot research terms such as "intelligent management" and "virtual reality" have emerged. It can be seen that smart education has changed from a single technology research model to a technology diversification application model.

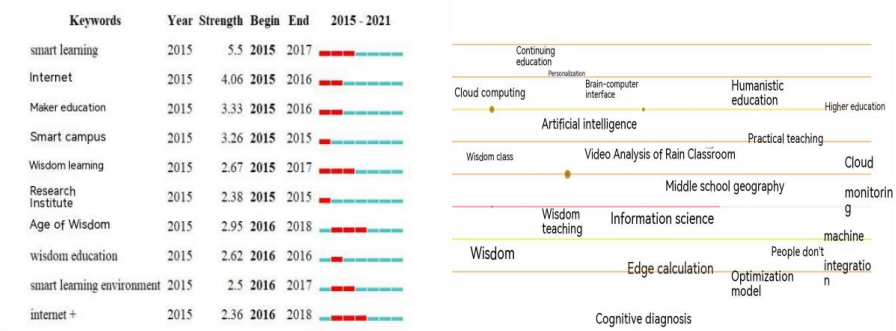

Figure 4 Smart Education Keyword Highlighted View; Smart Education Keyword Highlighted View

3.2 Analysis of research collaboration network

CiteSpace's clustering and time series two view methods can clearly show the research evolving trends over time, where the time series view can also present the changing structural relationship between nodes in the co-citation network and time, China's wisdom education research highly productive institutions is shown in Figure 5. From Figure 5, it can be seen that the research institutions in the literature on smart education have been widely distributed over the past seven years, and in order to better grasp the community in this academic field, we need to describe and analyze the high-producing institutions. The top ten academic institutions publishing papers are led by Beijing Normal University, with 100 papers, accounting for 21.32% of all journals, and it has carried out several academic weeks on wisdom education from 2016-2018; Jiangsu Normal University has 88 papers, accounting for 18.76%, and established the first Institute of Smart Education in China; East China Normal University has 64 papers, accounting for 13.43%, and many researchers are enthusiastic about teaching research in various aspects such as microlearning, smart learning and flipped classroom. In summary, Beijing Normal University, Jiangsu Normal University, and East China Normal University are the top three institutions in terms of the number of published papers, and they fully highlight their research advantages with more than 10% of the total. In addition, most of the top ten popular institutions are distinguished universities with the word teacher education in their names, which reflects that the research and practice of wisdom education in China is also paid extra attention in teacher education.

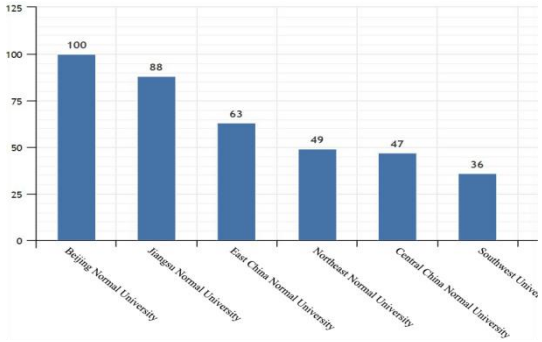

Figure 5 Highly productive institutions in smart education

3.2.1 Analysis of the time zone distribution profiles of research institutions and authors

In terms of research institutions, more than 60 universities and colleges have studied the field of smart education in depth over the past seven years, and especially former 985 or 211 institutions are very active in smart education research (see Figure 6). As can be seen in Figure 6, as early as 2015, teacher training colleges and universities such as Beijing Normal University and Jiangsu Normal University have established research centers specializing in smart education and conducting specialized scientific research in the field of smart education, and the ongoing research has produced many influential research results. In addition, institutions such as East China Normal University, Nanjing Normal University and Northeast Normal University have also begun to pay more attention to the field of smart education. Among them, the College of Open Education (East China Normal University) and the College of Information Science and Technology (Northeast Normal University) have become the core nodes of the institutional chronology through their own excellent research results, and institutions such as Southwest University have followed the pace and joined the research in the field of smart education after 2017, and gradually formed their own independent representative views on smart education. Overall, the development of the field of wisdom teaching in China is very rapid, and well-known universities with doctoral and master's degrees in educational technology have conducted more in-depth research on wisdom education during this period. It is worth noting that since 2020, Southwest University has also gradually become one of the leaders in the industry, showing an upward trend in the quality and quantity of articles published in the past two years, and accurately capturing the product design and teaching applications of smart education platforms.

Figure 6 Time zone mapping of smart education institutions

As can be seen from the authors of the study, there are as many as 60 researchers who have engaged in relevant research in the field of smart education, among which 7 have published more than 10 papers, with Professor Zhu Zhiting being the most prolific, with 29 publications, followed by Professor Chen Lin with 28, Professor Zhong Shaochun with 18, and Huang Ronghuai[7] 17, Yang Xianmin[8] Prof. Yang Xianmin, Prof. Peng Hongchao, Prof. Zhang Yi, and Prof. Zhu Zhiting. Among them, the early focus on smart education started in 2015, with Prof. Zhong Shaochun from Northeast Normal University and Prof. Chen Lin and Prof. Yang Xianmin from Jiangsu Normal University being the first to devote themselves to research on smart education. Also influential are Professors Rong-Huai Huang, Yun-Wu Wang and Hong-Chao Peng. In 2020-2021, the Center for Ethnic Education and Psychology Research at

Southwest University also began to turn into one of the new influential center points of research, represented by Professor Luo Shengquan, and this information coincides with the previous information on institutional mapping. In addition, the main publishing journals are shown in Figure 7 (right). 134 papers were published in Electrochemical Education Research, followed by 133 papers on China Electrochemical Education and 45 papers in Distance Education Magzines, which shows that wisdom education is one of the research representatives in the field of educational technology, and 30 and 28 papers were published in Modern Distance Education Research and Open Education Research respectively, indicating that wisdom education as a brand-new force for educational change is beginning to receive wide attention from experts and scholars and This shows that smart education as a new force for educational change is beginning to receive wide attention and unanimous recognition from experts and scholars.

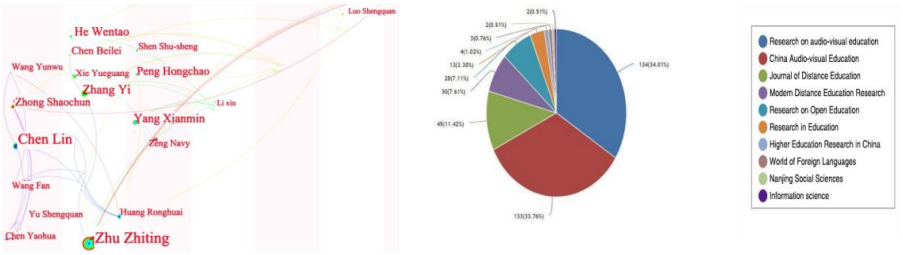

Figure 7 Time zone mapping of study authors; distribution of posting journals

3.3 Theme and domain co-occurrence network analysis

3.3.1 Keyword(topic) co-occurrence mapping analysis

While highly condensing the core and essence of an article, keywords also assume the responsibility of important indicators of bibliometric research. In this study, the Node Types are set to Keyword, the Time Slicing is set to 2015-2021, the time interval is set to 1 year, the data extraction is set to the top 50, and the keyword co-occurrence map of "smart education" is drawn through the above settings. The keyword co-occurrence mapping of "smart education" is shown in Figure 7. The frequency of keywords and the relationship between keywords in the graph are directly related to the area of the circle and the obviousness of the connecting lines, respectively, the larger the area, the higher the frequency of keywords, and the more obvious the connecting lines, the closer the degree of connection between keywords.[9] From the graph, we can see that the keywords with obvious nodes include smart education, artificial intelligent and smart learning, etc. After a simple classification, they can be divided into four categories, including environment construction, policy foundation, technical support and teaching research, among which environment construction includes smart campus, smart classroom and smart learning environment; policy foundation includes education informatization and core literacy; technical support includes artificial intelligence, Internet+, big data, digital twin and creator; teaching research includes smart teaching, rain classroom and flipped classroom, etc. These high-frequency keywords also build a community of current core areas of smart education, so the results of statistics and classification can also provide scientific data for subsequent more in-depth hotspots and trends research.

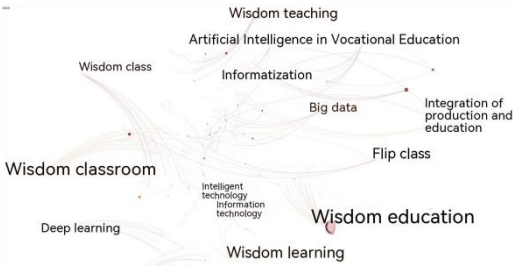

Figure 8 Key co-existence diagram of smart education

3.3.2 Analysis of time-series view of research frontiers (fields)

The chronological view can clearly present the changes of research hotspots in a certain field within a certain time period, which can help people see more intuitively the changes of research hotspots in the field of wisdom education in the past seven years, as shown in Figure 9, and the whole research can be divided into two stages: the first stage is from 2015-2017, and this stage can be regarded as the basic development stage of wisdom education research. It can be seen from the keywords of smart campus and teaching design that the research on smart education has gradually changed from the stage of theoretical exploration to the stage of practical application, and fruitful results have been achieved in the process of its practical application. The second phase is from 2017 to 2021, during which new breakthroughs in wisdom education research have been made and the keywords have changed to "artificial intelligence" and "Internet+". During this period, people began to focus on the impact of technology on the dominant role of teachers and used artificial intelligence technology to play this dominant role more effectively. The introduction of artificial intelligence has had a strong impact on the development of personalized learning and has gradually made it one of the most popular forms of learning. Compared to the previous phase, the changes in the organization of teaching and learning in this period will be revolutionary, as schooling has begun to shift gradually from traditional classroom teaching to individualized teaching and learning support.

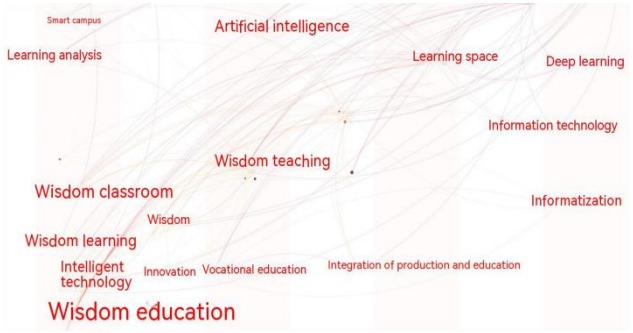

Figure 9 Time-series view of the frontiers of smart education research

4 Summary and outlook

4.1 Research summary

From the research status, China's wisdom education research started late, whether wisdom education is suitable for China's education development and whether it can truly and effectively improve the learning effect needs to be proved through practice; from the research theme, the keyword time zone chart shows that high frequency keywords are "smart classroom", "big data" and "artificial intelligence", while the keywords like "teaching strategy", "learning experience" and "learning experience" are more frequent. The number of keywords such as "teaching strategy", "learning experience" and "teaching design" is relatively low, which indicates that most of the current research on smart education is at the level of technical feature analysis, and technology is certainly important as the basis for the development of smart education, but students as the subjects of learning activities are also important in the development of smart education. Technology is important as the basis for the development of smart education, but students play an irreplaceable role as subjects of learning activities in the development of smart education, and smart education needs more teaching practice.[10] Smart education requires more pedagogical practices. Therefore, the implementation of smart education will be more meaningful only if the education model is thoroughly changed. From the perspective of research hotspots and development trends, the current rapid development of information technology is transforming education, and the deep integration of information technology and the classroom has effectively improved teaching effectiveness and learning efficiency. In the future, teachers and students will enter a new intelligent learning space, and the teaching environment, teaching organization mode and teaching evaluation system will also change. Smart education is not only the integration of intelligent technology and education, but also the comprehensive transformation and reform of the education field in the context of the future intelligent information era.

4.2 Future outlook

First of all, in terms of teaching mode, it is necessary to move from low adaptation of technology and teaching to high integration. The reason that makes it difficult to truly integrate teaching and technology is the lack of wisdom, the key to solve this problem and then achieve the ideal mode of technology realization and wisdom teaching is to meet the new needs of the development of wisdom education, in the teaching design to focus on the role of wisdom in teaching activities, follow the problem discovery, analysis and solution of the This also indicates that in the dimension of education objectives, it is necessary to cultivate talents with creative and critical abilities.[11] Secondly, it is necessary to move from mono-evaluation to multi-dimensional evaluation. The current evaluation system is mainly based on the three-dimensional curriculum objectives, and pays less attention to the evaluation of wisdom ability, making it difficult to enhance students' wisdom ability. Therefore, a multi-dimensional evaluation system with wisdom ability as the core needs to be formed in the development of wisdom teaching, and comprehensive evaluation in the form of thinking maps, virtual learning communities and resource websites can be used to establish a new teaching evaluation system centered on students' core literacy.[12] Finally, in terms of teaching environment, actively build and apply a wisdom teaching environment. The wisdom teaching environment is a high-end environment form with wisdom technology as the core which is a new trend of learning

environment development in the context of information-based education. The wisdom upgrade of the classroom environment is an important part of the development process of wisdom teaching. Regarding the current problem of insufficient multiple intelligent learning systems in the classroom, such as intelligent learning terminals, intelligent learning software as well as intelligent management platforms and intelligent learning resources, it is necessary to introduce new big data-based analysis methods, and then create classroom intelligent teaching activities that rely on cognitive tools, and want to build a future wisdom classroom environment In order to build a smart classroom environment and a smart teaching development model in the future, it is necessary to rely on these smart databases to be realized.

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