A Bibliometric Analysis of Rural Teachers' Digital Literacy Based on CiteSpace

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Abstract: Against the backdrop of the rapid penetration of artificial intelligence (AI) technology into the field of education, the digital literacy of rural teachers has become a key factor in promoting educational equity and quality. This study focuses on the issue of digital literacy among rural teachers and employs CiteSpace, a bibliometric analysis tool, to conduct an in-depth analysis of relevant literature. The findings reveal that although AI technology offers possibilities for enhancing the digital literacy of rural teachers, there are still deficiencies in their technological awareness, operational capabilities, and depth of application. CiteSpace analysis indicates that AI technology plays a positive role in improving the digital literacy of rural teachers by providing personalized learning resources and interactive platforms. However, popularizing technology, infrastructure construction, and establishing a professional support system remain key challenges in the enhancement process. In conclusion, the study suggests that future strategies should be explored based on the characteristics of rural education to more effectively apply artificial intelligence, to comprehensively improve the digital literacy of rural teachers, thereby narrowing the urban-rural educational gap and promoting educational equity.

Keywords: Artificial Intelligence; Rural Teachers; Digital Literacy; Enhancement Strategies

1. Introduction

In today's era, the rapid development of artificial intelligence technology is profoundly influencing the transformation of the educational field. Especially in rural education, the application of artificial intelligence holds significant importance for enhancing the quality and literacy of rural teachers. The Chinese government places great emphasis on the development of rural education, having introduced a series of policy documents that explicitly propose implementing digital empowerment actions for teacher development. These actions aim to utilize modern information technology to raise teachers' awareness of actively responding to new technological changes and improve rural teachers' digital literacy.

Currently, the rural teacher workforce in China generally faces the issue of low digital literacy. As the main force driving rural development, the level of digital literacy among rural teachers will directly affect the overall quality of future rural development. This study found that domestic research on the pathways to enhance the digital literacy of rural teachers mainly focuses on the training and educational applications of digital technology. In contrast, research combining artificial intelligence with this field is still insufficient.

Therefore, this research takes relevant journal literature from China National Knowledge Infrastructure (CNKI) from 2018 to 2024 as samples and visually analyzes the research literature on enhancing digital literacy among rural teachers in China using CiteSpace software and bibliometric methods. It explores the development overview of rural teacher digital literacy research since 2018, presenting the current state, hotspots, and development trends of research on enhancing the digital literacy of rural teachers. Building on this foundation, the study uses artificial intelligence as a starting point and focuses on the enhancement of rural teachers'

quality and literacy, analyzing the challenges and opportunities faced by rural teachers, and discussing how to leverage artificial intelligence technology to improve rural teachers' educational teaching capabilities, professional literacy, and overall quality.

2. Research Design

2.1 Data Source
The data used in this study is sourced from the China National Knowledge Infrastructure (CNKI). Advanced search queries were conducted using the topics and keywords "rural teachers' digital literacy," with data ranging from 2018 to 2024. After manual screening to exclude duplicate samples and non-research articles such as conference papers, a total of 305 eligible documents were selected as the sample for this study.

2.2 Research Tools
This study utilizes CiteSpace, a science text mining and visualization analysis software developed by Professor Chaomei Chen of Drexel University, USA (version 6.2R4), for data processing and visualization analysis.

2.3 Data Processing
The selected documents were imported into CiteSpace for analysis. The study conducted keyword contribution prominence clustering timeline analysis. The specific settings in the software were as follows: "Period" was set from "2018 to 2024," with a time slice unit of 1 year, and the node type was set to keywords. In the keyword contribution analysis and keyword prominence, the nodal threshold was set to "TopN=50," representing the selection of the 50 most frequent units in each time partition to generate and analyze the corresponding network graphs. The network pruning methods used were "Pathfinder," "Pruning Sliced Networks," and "Pruning the Merged Network," with all other parameters remaining unchanged. In the keyword clustering and keyword timeline, the nodal threshold was set to "g-index=15," and the network pruning methods used were "Pathfinder" and "Pruning Sliced Networks," with all other parameters remaining unchanged. The final results were presented visually.

3. Research Results and Analysis
This study employed CiteSpace 6.4, a visual literature analysis software, to conduct a visual analysis of domestic literature on rural teacher research from 2018 to 2024. The specific operations included five aspects: First, a statistical analysis of publication volume was conducted to reflect the number of publications, trends, and researcher attention in the field of rural teacher research. Second, a co-occurrence analysis of keywords was performed to grasp the research hotspots in the field of rural teacher research in China. Third, a burst analysis of keywords was conducted to clarify the development process and changes of related keywords in different stages of the rural teacher field. Fourth, a keyword clustering analysis was performed to reveal the boundary relationships between rural teacher research themes and grasp the development trends of rural teacher research in China. Through the analysis of these five aspects, a clear picture of the landscape and situation of rural teacher research in China from 2018 to 2024 can be presented.

3.1 Publication Volume and Trend
The annual increase or decrease in the number of publications in a certain field can reflect the researcher's attention to the field to a certain extent. This paper statistically obtained the distribution map of annual publication volume for rural teacher research in China over the past decade (see Figure 1).

Figure 1 shows the publication volume and trend of rural teacher digital literacy research from 2018 to 2024. According to the data in the chart, the publication volume was relatively low and stable from 2006 to 2020. The peak in 2021 may be related to the "Opinions on Strengthening the Construction of Rural Teacher Teams in the New Era" [1] released in 2020. This document emphasized the importance of improving the quality of rural teachers, including training and support in digital literacy. Additionally, 2021 was the first year, which pointed out the need to promote the construction of educational

informatization, further driving the development of rural teacher digital literacy research. From 2022 to 2024, the publication volume of rural teacher digital literacy research showed a significant increase, which can be attributed to the combined effect of multiple factors. The publication of research results such as "Factors Influencing Rural Teachers' Digital Literacy and Strategies for Improvement" [2] further revealed the connection between policy and practice, analyzing how to promote the professional development of rural teachers through policy guidance and resource support. The interaction of these policies and research provided a solid theoretical and practical foundation for the improvement of rural teachers' digital literacy, leading to a surge in publication volume during this period and forming a research peak. Furthermore, the widespread application of artificial intelligence and cloud computing in the field of education has brought new research perspectives and methods for researchers. Future trends in rural teacher digital literacy research may focus more on practical applications and sustainable development, with researchers dedicated to exploring the deep integration of emerging technologies with teaching practices and how to optimize teacher training models through data-driven decision-making, thereby continuously improving rural teachers' digital literacy to meet the educational needs of an information society.
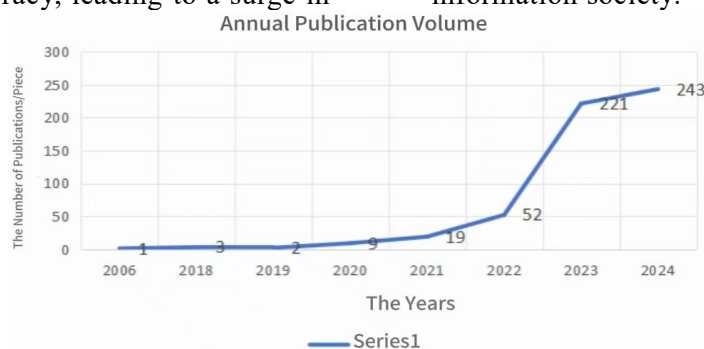

Figure 1. Statistical Analysis of Publication Volume on Rural Teachers' Digital Literacy Research from 2018 to 2024

3.2 Keyword Co-occurrence Analysis

In bibliometrics, statistical analysis of high-frequency keywords in a field's literature can determine the research hotspots of that field. Keywords are natural language words that express the thematic concepts of literature, and the collection of keywords can reveal the overall characteristics and development directions of the field to a certain extent. Therefore, bibliometric research often uses keyword analysis as an indicator of literature research. The frequency of a keyword can determine the development trends of the field. Generally, the higher the frequency of a keyword, the higher the attention to that research field, and it may be a hotspot of the field. After statistical analysis of the relevant literature, the frequency distribution of keywords can be obtained, and the high-frequency keywords can be determined as the research field by sorting them from high to low frequency.

This study used CiteSpace, with keywords as nodes and a time partition of 7 years, with a threshold of Top50, to draw a high-frequency keyword co-occurrence network, that is, a knowledge map of hot topics in rural teacher research. There are 207 keyword nodes in the graph, and the lines between nodes represent the association of keywords, with a total of 476 lines. The size of the nodes indicates the frequency of keyword occurrence; the larger the circle, the more frequently the keyword appears, indicating that the field is highly concerned by scholars and the research is relatively mature.

From the Figure 2 keyword co-occurrence map, it can be seen that the "rural teachers" node is the largest, indicating that it appears the most frequently, and other keywords are all related to key content. Over the past decade, the hotspots in the field of rural teacher research have been rural education, digital literacy, and digital transformation. Rural education, as an important part of

China's education system, undertakes important functions such as providing talent and cultural conditions for rural development. Against the backdrop of the current rural revitalization strategy, the role of rural education is becoming more prominent. It can improve the quality of rural human capital and stimulate the potential of rural human resources, providing strong talent support for the comprehensive advancement of rural revitalization. Rural teachers play a crucial role in promoting the development of rural education and the modernization of education. They are not only disseminators of knowledge but also shapers of rural culture and spirit.
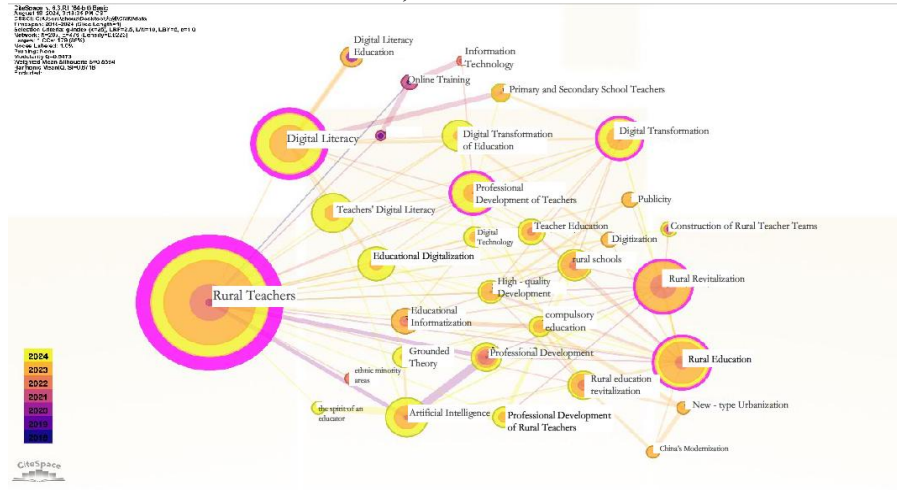

Figure 2. Co-occurrence Map of Keywords in Rural Teacher Research

3.3 Frequency and Centrality of Keyword Co-occurrence

The frequency of keyword co-occurrence refers to the number of times two or more keywords appear simultaneously in a certain literature or knowledge field, while centrality indicates the importance of a keyword in the entire literature network. By ranking the keywords in relevant literature on rural teachers in China in the past nearly seven years according to their co-occurrence frequencies and centralities, it is possible to further clarify which research topics are becoming research hotspots.

The statistical results shown in Table 1 indicate that the appearance frequencies of four keywords - rural teachers, digital literacy, rural revitalization, and rural education - are significantly higher than those of other keywords. As shown in the table 1, the centrality of "rural teachers" is the highest, reaching 0.96, while the centralities of other keywords are significantly lower than that of "rural teachers". It can be seen that the research topics in the field of rural teachers in China are relatively single, mainly focusing on four aspects: rural teachers, digital literacy, rural revitalization, and rural education research. The research achievements in other directions and topics are not significant and need to be strengthened. Overall, the current research on rural teachers in China has not entered the stage of diversified development with independent directions and multiple parallel themes.

Table 1. Frequency and Centrality of Keywords in Rural Teacher Research

Ranking	Frequency	Centrality	Year	Keyword
1	123	0.96	2018	Rural Teachers
2	43	0.26	2019	Digital Literacy
3	29	0.17	2021	Rural Revitalization
4	29	0.16	2022	Rural Education
5	21	0.1	2020	Artificial Intelligence
6	18	0.1	2022	Teacher Professional Development
7	17	0.03	2023	Teacher Digital Literacy

8	15	0.07	2022	Digital Transformation
9	13	0.07	2023	Education Digitalization
10	12	0.07	2022	Rural Schools
11	10	0.02	2020	Professional Development
12	9	0.04	2023	Education Digital Transformation
13	9	0.04	2022	Rural Education Revitalization
14	8	0.01	2022	High-Quality Development
15	7	0.03	2022	Teacher Education

Combined with the reading of literature materials, it is found that in recent years, to narrow the gap in teacher quality between urban and rural areas and ensure that every rural child can receive a fair and high-quality education, China has issued the "Rural Teacher Support Plan (2015 - 2020)" [3], focusing on promoting the construction of the rural teacher team. However, affected by factors such as unbalanced urban and rural development and backward school running conditions, the current rural teacher team still faces prominent problems such as low quality and insufficient allocation of high-quality resources, restricting the sustainable and healthy development of rural education. To build a rural teacher team with high overall quality and strong teaching ability, it is necessary to conduct targeted training for rural teachers in line with the development trend of education in the new era. The National Education Work Conference proposed to implement the National Education Digitalization Strategy Action, and the education digitalization strategy has gradually become an important means to promote the innovative development of education. This means that teachers need to possess high digital literacy to use digital technology to teach better.

In conclusion, to promote the development of rural education in China, it is necessary to build a teacher team with sufficient scale, solid professional knowledge, and high digital literacy, accurately grasping the key links in the construction of the rural teacher team. It is necessary not only to solve the problems of low quality and insufficient allocation of high-quality resources of rural teachers but also to actively face new challenges, demonstrate the connotation of current teachers, combine digital means in the new era with the digital education experience of urban teachers, promote the improvement of rural teachers' digital literacy, and actively promote the development of rural education.

3.4 Analysis of Keyword Emergence

Keyword emergence analysis explores the development process of literature keywords through citation volume over a period of time, from which the rise and fall of a certain keyword can be observed. Arranging keywords in chronological order can show the research focuses and their changes in different stages of the research field.

Using the CiteSpace software for keyword burst analysis can detect the research frontiers in a certain field. By running CiteSpace, 25 node burst words with high burst values are obtained. Combined with their corresponding original literature and the evolution of burst words, it can be seen from Figure 3 that the research trends of rural teacher development can be roughly divided into three stages.

The first stage is from 2018 to 2019. The hot keywords in this stage of research are "Network-based Teacher Professional Development", "Internet +", and "Internet + Education", reflecting that the means of using Internet technology for teacher training and educational resource integration in China have begun to increase. Researchers have gradually started to explore how to change the traditional education model through the Internet and promote educational informatization. Educational informatization is an important means to achieve educational modernization, and "Internet + Education" is an important manifestation of educational informatization under the background of the new normal of education. To this end, relevant departments have successively rolled out a series of policy decisions in support of the construction of educational informatization [4].Due to the unbalanced

development of educational resources in China during this stage and the need to deepen teachers' educational concepts and improve their information utilization abilities, most of the research focused on case studies and theoretical discussions, and the achievements of educational information were not obvious and urgently needed in-depth development [5].
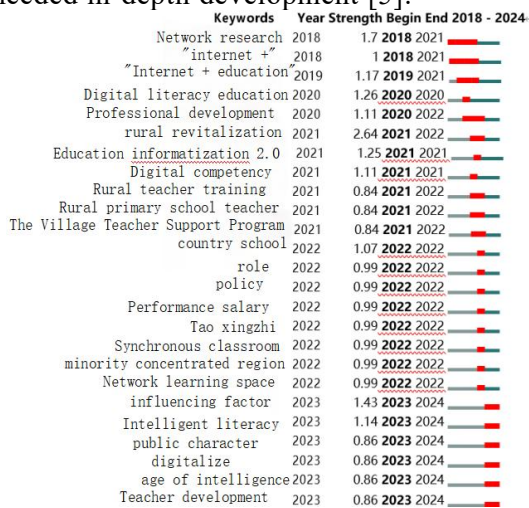

Figure 3. Emergence Map of Keywords in Rural Teacher Research

The second stage is from 2020 to 2021. The hot keywords in this stage of research are "Digital Literacy Education", "Professional Development", "Rural Revitalization", "Rural Teacher Training", and "Rural Teacher Support Plan". The research in this stage involves how teachers can improve teaching quality by enhancing their digital skills and how this improvement affects students' learning outcomes. To this end, the Ministry of Education issued the "Rural Teacher Support Plan (2015 - 2020)" [3], aiming to promote local changes in rural teacher training models and improve the

effectiveness of rural teacher training. This means that rural teachers need to improve their digital teaching skills and quality development based on mastering professional basic knowledge to promote the development of rural education and rural revitalization.

The third stage is from 2022 and onwards. The hot keywords in this stage of research are "Rural Schools", "Intelligent Literacy", "Digitalization", and "Teacher Development". Promoting intelligent education is a systematic project, and teachers are a key element, reflecting the adaptation and integration of the education field to scientific and technological progress and the pursuit of improving education quality and efficiency and realizing personalized teaching. Therefore, teachers need to possess sufficient digital literacy to better improve teaching quality. Especially for rural teachers, improving their digital literacy is a must.

3.5 Keyword Cluster Analysis
Cluster analysis of keywords can clarify the relevance of the research topics in the research field and reveal the boundary relationship between the research topics. That is to say, through the research and analysis of the main keywords, the purpose is to better grasp the current development trend of rural teachers' digital literacy, in particular, using CiteSpace for recent related to rural teachers' digital literacy research publications cluster analysis, to further clarify the rural teachers' popular words in the field of digital literacy research, help researchers understand the evolution of related research topics.
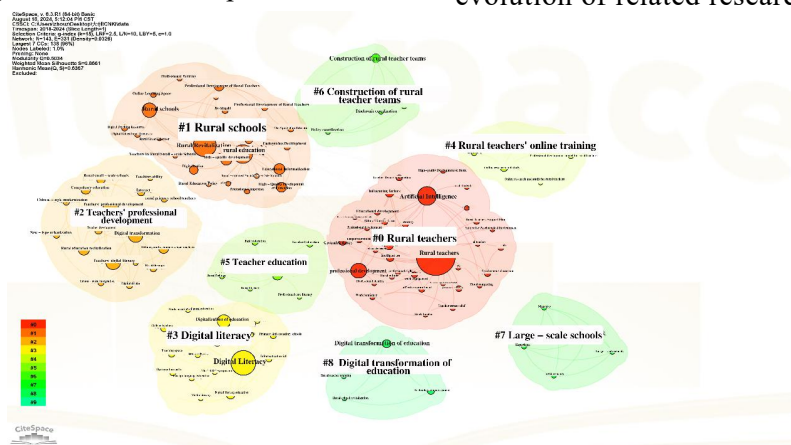

Figure 4. Keyword Clustering Map of Research on Digital Literacy of Rural Teachers

For keywords through the LLR algorithm clustering, capture the eight clusters (as shown in Figure 4), the eight cluster keywords processing, through the analysis can be divided into three categories, (1) digital literacy skills research: # 3, # 8, (2) teacher professional development research: # 0, # 2, # 4, (3) rural education construction research: # 1, # 5, # 6, # 7,

3.5.1 Research on digital literacy skills

Clustering # 3 (digital literacy) and # 8 (digital transformation) highlight the research focus on digital literacy skills. Keywords such as "information processing", "technology application", and "online collaboration" indicate the skills and qualities that teachers need to master in the digital age. The rapid development of digital technology has formed a huge wave of digitalization in the field of education, which contains the practical value of promoting the high-quality development of rural education. At present, the digital transformation faced by rural education in China not only points to the reform of teaching technology but also requires teachers to actively break through the practical dilemma of "resources and quality" in digital teaching.

Further, the Blue Book on Education Development and Rural Revitalization: A Report on Chinas Education Development and Rural Revitalization (2022~2023) [6], it reveals the challenges of rural education in technology application and highlights the need to enhance teachers digital literacy through professional development activities. As we can see, improving the digital literacy skills of rural teachers is not only an important direction of education policy but also a necessary condition for realizing the revitalization of rural education.

3.5.2 Research on teacher professional development

In the research on the field of professional development of rural teachers, clusters # 0, # 2, and # 4 focus on how teachers can achieve personal growth and skill improvement in the digital age. In these clusters, the study highlights the importance of "professional development" with a focus on the design and implementation of "training mechanisms". It points out that teachers need to adapt to the changing educational environment through systematic career planning and continuous learning activities. At the same time, it focuses on the concept of "lifelong learning" and emphasizes that teachers should continuously update their knowledge and skills during their careers. In this cluster, research explores how to establish an effective teacher training system to ensure that teachers can obtain the necessary support and resources to improve their digital literacy. In the digital teaching environment, the professional development of rural teachers requires not only continuous learning and self-improvement at the individual level but also structural support at the education system level and the innovation of training mechanisms. Through these comprehensive measures, we can ensure that rural teachers can adapt to the requirements of educational information, improve the quality of teaching, and ultimately promote the all-round development of students.

3.5.3 Research on rural education construction

Clusters # 1, # 5, # 6, and # 7 focus on the development and challenges of rural education, the allocation of rural education resources, and the shortage and imbalance of resources are the main problems faced by rural education. There is a big gap in the construction of information infrastructure in rural schools, such as "Promoting Education Equity and Improving the Quality of Education" [3] In, highlighted the role of the government in promoting equity in rural education, including developing policies that benefit rural teachers and students, as well as providing the necessary financial support. By optimizing the allocation of resources and improving the utilization efficiency of educational resources, the development of rural education can be promoted. The digital literacy of rural teachers is not only the need for the teachers' personal development but also the key factor in promoting the modernization of rural education. Therefore, we must pay attention to the digital skills training of rural teachers, and strengthen the construction of education information infrastructure, to provide strong support for the revitalization of rural education.

3.6 Timeline View Analysis

The main function of the timeline view is to present the correlation among individual clusters and the cluster changes across different periods.
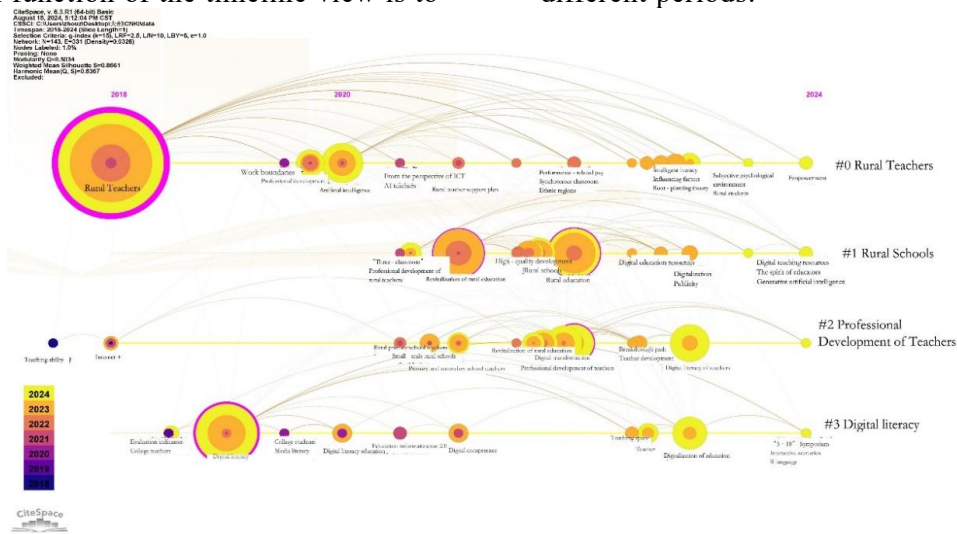

Figure 5. Timeline Chart of Rural Teacher Research

Converting the view into a timeline view after clustering yields the progression of the following three clusters, as shown in Figure 5. Cluster # 0 Village teachers: This cluster mainly revolves around the core concept of "village teachers", involving their work boundaries, professional development, and other aspects.

Clustering # 1 rural teachers and # 2 rural schools talk more about the status quo and development path of rural schools and focus on the professional growth of teachers. Cluster # 3 Digital Literacy: "Digital literacy" is the core concept of this clustering, and it also involves "media literacy", "education informatization" and other related issues. With the popularization and application of information technology, having good digital literacy has become one of the necessary abilities of modern teachers. Through various training activities, it is helpful to improve teachers' ability to use digital tools to assist in teaching, to better meet the learning needs of students in the new era. At the same time, with the implementation of the "Internet +" strategy, more and more high-quality education resources begin to tilt to rural areas. However, to serve these resources, the a digital divide in rural areas. This requires us to not only pay attention to the construction of hardware facilities but also pay attention to the optimization of the software environment, especially to improve the digital literacy level of teachers and students.

4. The Evolution Trend and Enlightenment of the Digital Literacy Improvement of Rural Teachers

Combined with the above visual analysis of the number of documents and the keywords, the digital literacy of rural teachers is gradually shifting from the passive acceptance stage to the stage of active adaptation and exploration of new technologies. It is of practical significance to continue to find more appropriate methods to improve the digital literacy of rural teachers. To improve the quality and literacy of rural teachers, we should fully consider China's national conditions, not only make good use of government policy support, but also develop artificial intelligence, to realize the awareness, specialization, and application of rural teachers to improve their digital literacy.

4.1 Promote the Awareness of Rural Teachers' Improvement of Digital Literacy

Improving the awareness of digital literacy of rural teachers is crucial to the overall improvement of their digital literacy. Awareness awakening is the premise of action. Only when rural teachers deeply realize the importance of digital literacy, can they take the initiative to learn and apply digital technology, to optimize

teaching and improve the quality of education. This awareness promotion helps to stimulate teachers' internal motivation, promote their professional growth in the digital education environment, and lay a solid foundation for rural education informatization.

To promote the awareness of the improvement of digital literacy of rural teachers, it is necessary to help rural teachers form self-awareness of the digital transformation of education, self-reflection on the digital status of rural education, and rational examination of the nature of educational digital technology. [5]

The promotion of digital literacy awareness is crucial to rural teachers. It not only promotes educational equity and enables rural students to obtain high-quality educational resources, but also is the key to rural revitalization and talent training.

4.2 Promote the Professionalization of the Digital Literacy Development of Rural Teachers

Compared with other research directions in the field of education, the improvement of digital literacy of rural teachers in China is relatively insufficient. From the international perspective, there are different social, cultural, and economic development differences in the improvement of rural teachers' digital literacy and conclusions. How to localize and innovate it will be the direction of Chinese efforts in the future, among which the development of artificial intelligence is an important channel for it to become a reality. The professional development level of rural teachers is an important standard to measure the quality of rural teachers, and also a key factor in determining the quality of rural education [7] China's policies need to pay more attention to the cultivation of rural teachers digital literacy. In addition, to increase the research on artificial intelligence, promote the professional development of rural teachers, and form an influential research team with professional ability.

4.3 Promote the Application of Artificial Intelligence in the Improvement of Digital Literacy of Rural Teachers

According to the statistics of the number of digital literacy research articles of rural teachers, digital literacy, and artificial intelligence have only been paid attention to by researchers in the last two years, which shows the importance of promoting the application of artificial intelligence in the improvement of digital literacy of rural teachers. Advanced digital technologies such as artificial intelligence and virtual simulation are deeply integrated with education and teaching and grow together. They break the boundaries of traditional physics classrooms and expand to a broad network teaching field rich in digital characteristics. This change to originally static, plane knowledge content becomes solid and dynamic, greatly enhances the attraction and influence of teaching, promotes the teaching mode innovation and evolution, leading the classroom in the direction of a more efficient, interactive transformation, enhances teachers' digital teaching ability, promote rural teacher professional development.

To effectively improve the digital literacy of rural teachers and promote the development of rural education informatization in China, multi-angle and all-round methods are put forward. From the perspective of policy-making, such as the development of special planning and financial support; from the perspective of educational training, such as combining online and offline training and customized courses; from the perspective of technical support, such as the provision of intelligent teaching tools and resource sharing platform; from the perspective of practical application, such as pilot demonstration projects and teaching case sharing; from the perspective of evaluation and feedback, such as the establishment of evaluation system and continuous optimization of AI education and training content and teaching methods; from the perspective of social cooperation, encourage school-enterprise cooperation and public welfare projects.

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