Data Mining and Professional Development: Research Hotspots and Trends of Digital Literacy of Rural Teachers

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Abstract:

Along with information technology iterative update, and the rapid penetration into various fields. Improving rural teachers 'digital literacy has become the core element to realize urban-rural education equity. The digital literacy of rural teachers has been paid more and more attention by the academic circle and society. With the help of visualization analysis software Cite Space6.3.1, bibliometric analysis was carried out on the research results of rural teachers 'digital literacy in the past ten years (2014 to 2023). Based on Popper's three world theory and the "second-order science" paradigm, The evolution and progress of the theme of rural teachers 'digital literacy research were deeply analyzed by using Price's formula. The number of published papers shows the characteristics of stages, the distribution of research authors and research institutions is wide, most of them are normal universities, and cooperative research has gradually become a development trend. The research focuses on the topics of data mining, technical support and ascension path of rural teachers' digital literacy. It also reflects the research trends of rural teachers' digital professional development, digital training, and enhancement of digital resource integration ability. Future research should further strengthen cooperation, focus on digital literacy goals, improve rural teachers' ability of data thinking and data mining, improve the training system, pay attention to professional development, and build an overall improvement framework for rural teachers 'digital literacy.

Keywords: village teachers; digital literacy; data mining; digital professional development; bibliometric analysis

INTRODUCTION

Rural teachers are important promoters of promoting the digital transformation and high-quality development of rural education, and are the backbone of narrowing the urban-rural education gap and realizing high-quality and balanced development. With the accelerated iterative upgrading of information technology, the promulation of teachers 'digital literacy standards with information and data literacy as the important content, crossing the digital divide and improving rural teachers 'digital literacy must be solved to promote education digitalization and realize education equity.

In the past ten years, the related research on rural teachers 'digital literacy has focused on the following three aspects: first, it is the research on the role orientation and technology adaptation of rural teachers under the background of digitalization. [1-2] Second, it is rural teachers' information and data quality can assign value and connotation of the professional development.[3] Third, it is data mining and professional development path research that constitute the important content of rural teachers' digital literacy.[4]

To sum up, scholars have discussed rural teachers 'digital cognition, technology adaptation difficulties of digital literacy improvement, data mining and professional development crisis, and breakthrough directions from multiple perspectives. However, what are the characteristics of the relevant research results? What are the research questions? Is the research focused? Where does future research go? It's not clear. This paper uses bibliometric methods and visual analysis software CiteSpace to systematically sort out the relevant research on rural teachers 'digital literacy in the past 10 years, and analyzes the characteristics and trends of data mining and professional development in rural teachers 'digital literacy, In order to provide reference for the research and improvement of rural teachers 'digital literacy.

METHODS, TOOLS AND DATA COLLECTION

Research Methods and Tools

Cite Space is based on the bibliometrics of a specific research field, from the research hotspots, frontiers and trends and other dimensions of analysis, in order to find the field of concern, change process and future trend of scholars in this discipline. A visual map is drawn to analyze the internal mechanism of the development and evolution of the discipline research and predict the future development of the discipline. It is intuitive, scientific and clear.

In this study, Cite Space 6.3.1 software is used to calculate the distribution of authors, research institutions, keyword co-occurrence, keyword clustering, and emergent words. Based on Popper's Three Worlds theory, vivid and intuitive visual

images are interpreted with the help of the visualization map of the development and evolution of rural teachers' digital literacy and the "second-order science" paradigm with a higher degree of abstraction. This paper explains the research hotspot and future prospect of rural teachers' digital literacy.[5]

Data Collection

In order to collect more comprehensive research literature on the digital literacy of rural teachers in China, this paper uses the database of China National Knowledge Infrastructure (CNKI) as the data retrieval source. CNKI is one of the largest academic resource databases in China and an indispensable representative tool for Chinese scholars to study, research and write papers. Set up the subject search in the advanced search, and the search statement consists of two groups: The first group is "rural teachers" , the second group is "digital literacy", "data literacy", "artificial intelligence", "big data", "artificial intelligence", "Internet" and other words related to digital technology, and the two groups are "and", the time is set from January 1, 2014 to December 31, 2023, a total of 524 literatures were retrieved. After manual screening and deletion of atypical research literature such as conference papers and newspapers and literature not strongly related to this study, 407 valid literatures were finally obtained and used as analysis data sources.

RESEARCH RESULTS AND ANALYSIS

The Number of Publications Has a Phased Feature and Has Gradually Stabilized in Recent Years

The annual number of published papers can directly reflect the degree of scholars' attention to the research topic in a specific period, and show the dynamic change, development speed and overall development trend of the research in this field. As shown in Figure 1, in past decade, the number of published papers has shown an overall upward trend, with an obvious peak value. Can be roughly divided into three stages.

The first stage, 2014-2018, is a period of rapid development. At this stage, the annual number of published documents showed a geometric increase. The "Internet + education" has become a hot topic for educators to discuss and research. The second stage, 2019-2021, which is the period of twists and turns, and the research in this stage presents the characteristics of phased decline and fluctuations. The number of published papers will peak in 2021. This may be directly related to the COVID-19 outbreak at the end of 2019. Offline teaching stalled, and the Ministry of Education has issued a work notice of "no suspension of classes" to actively carry out online teaching, prompting many educators to actively carry out digital teaching, accelerating the digitization of education and the research in the field of digital literacy of rural teachers.It promotes the research in the field of rural teachers' digital literacy. The third stage, from 2022 to 2023, is the detailed stable period. during which the number of published literatures tends to be stable, and the discussion on rural teachers' digital literacy gradually turns to the micro level. Scholars pay extra attention to the actual state of the development of rural teachers' digital literacy and the way to improve it, indicating that the related research tends to be stable.
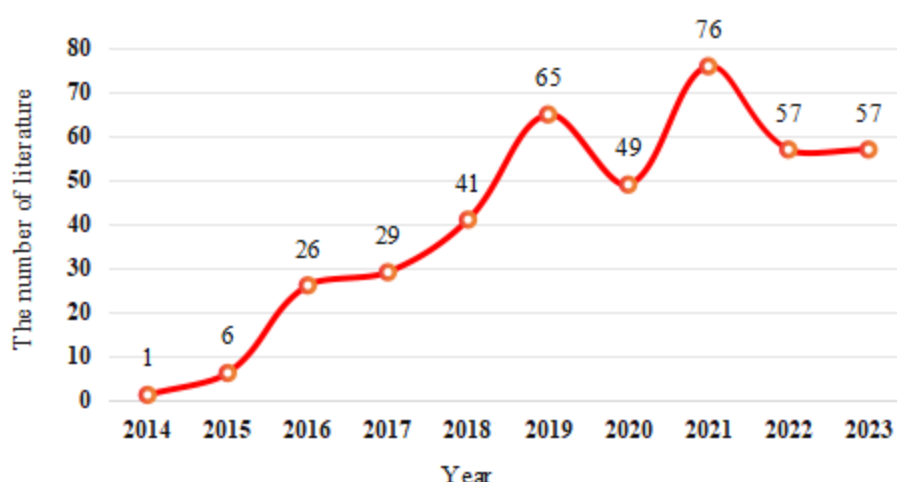

Figure 1. Annual publication trend of literature in recent ten years

The Published Journals and Greatly Cited Literatures Are Relatively Concentrated

By analyzing the data of CNKI, there are 14 journals that have published 5 or more papers related to rural teachers' digital literacy in China, including 4 core journals. "China Educational Technology" published 14 related papers, ranked first. As

shown in Table 1. The 407 valid literature selected in this study involved 243 journals, except for the 14 journals listed in Table 1, the other journals were published sporadically.

Table 1. Distribution of published journals (5 or more papers)

Serial Number	Journal	Number of publications (articles)	Serial Number	Journal	Number of publications (articles)
1	China Educational Technology	14	8	Learning Weekly	6
2	Rural Economy and Science-Technology	10	9	Chinese Information Technology Education	5
3	China Adult Education	8	10	Survey of Education	5
4	The Inservice Education and Training of School Teachers	6	11	e-Education Research	5
5	Western China Quality Education	6	12	Teaching & Administration	5
6	Kao Shi Zhou Kan	6	13	Ethnic Education of China	5
7	New Curriculum	6	14	Journal of Teacher Education	5

By analyzing the citation frequency of the literature, it can be judged the situation of the literature being recognized and concerned by the academic circle. According to the citation frequency ranking of CNKI database, the top 10 cited literatures are all literatures in 2022 and before. In order to ensure the objectivity and timeliness of the research, in this paper, the top 6 cited literatures and the top 2 cited literatures in 2022 and 2023 were selected, and 10 highly cited literatures were finally obtained, as shown in Table 2 for details.

Table 2. Frequently cited literature on the rural teachers' digital literacy

Serial Number	Literature sources	Cited frequency	Serial Number	Literature sources	Cited frequency
1	Jun T. et al，2019	91	6	Qiao Wen Z.，2017	60
2	De Kun J.，2018	86	7	You Qun R.et al，2022	57
3	Yong Gu W.et al，2020	76	8	Jing Zh. et al，2023	50
4	Li Yan L.et al，2021	74	9	Hua L.，2022	33
5	Jiang Hua L.et al，2018	64	10	Ze Ping P.et al，2023	34

Among the 10 highly cited literatures, 9 are core journals. Through the analysis of the above core papers and highly cited literature, It shows that the scholars mostly pay attention to the mode construction of the integration of information technology

and rural education and the value implications and impact factors of the improvement of rural teachers' digital literacy from the theoretical level, but there are few discussions from the practical perspective.

Research Authors and Institutions Are Widely Distributed, and There Is a Trend of Cooperation

According to the calculation formula proposed by scholar Price about determining the core author：M=$0.749\sqrt{Nmax}$ （M stands for the number of papers, N represents the number of papers by core authors）. By using CiteSpace software to analyze the literature, it can be seen from the formula that M=1.498, take the integer 2. The authors with two or more publications are considered core authors. There are 25 authors totally, with 56 papers, accounting for 13.76% of the total number of articles in the study, which is well below Price's law's 50 percent core authorship target. It shows that the core author group has not yet formed in the research of rural teachers 'digital literacy in China. At the same time, it can be seen from the node connection that there is a correlation degree between authors and a trend of cooperation.

The node type is set as "institution", and the analysis of 407 valid literatures shows that research institutions are widely distributed, including universities, primary and secondary schools. The authors of the papers are mostly concentrated in the educational technology field of teacher-oriented universities and scientific research institutions. As shown in Figure 2, the College of Educational Technology of Northwest Normal University published the most papers, with a total of 6.According to Derek John de Solla Price's Law for determining the core institution：

M=$0.749\sqrt{Nmax}$ （N is the quantity of documents issued by core institutions）.It can be seen from the calculation that the minimum number of core institutions published is 2, with a total of 30 institutions, and 76 articles, accounting for 18.67% of papers published totally, indicating that the core institutional group has not been formed in China.

According to the cluster analysis of the cooperation status of research institutions, it can be seen from the view analysis that there are 203 nodes, 34 connections, and 0.0017 connection cooperation density. It shows that there is less cooperation among publishing institutions, and only some research institutions have established cooperative relations. Most of the researchers come from college teachers, and few rural educators go deep into front-line practice. On the whole, researchers and institutions are scattered, lacking systematic, long-term and cooperative systematic exploration, and have not yet formed a strong cohesive cooperation network across institutions and fields.[6]
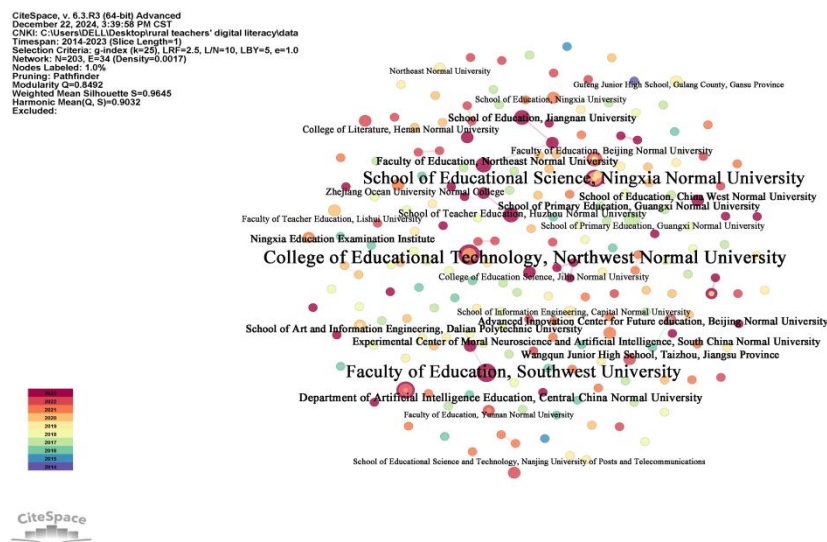

Figure 2. Visualization of rural teachers' digital literacy research institutions

Research Hotspots of Rural Teachers' Digital Literacy

Research hotspots can be refined through keyword co-occurrence and cluster analysis, and the importance of nodes can be measured by keyword centrality. The Cite Space software "keyword" node was used to analyze the literature, and the ranking of frequently used words in digital literacy research of rural teachers in China was obtained (see Table 3), the map of keyword co-occurrence knowledge (see Figure 3) and the graph of keyword cluster analysis (see Figure 4). The keywords with high frequency and strong centrality are rural teachers, Internet +, rural education, rural teachers, professional development, etc., which reflects the changes in the focus areas in the process of rural teachers' digital literacy research.

Table 3. Top 10 high-frequency keywords in domestic literature on rural teachers' digital literacy

Serial Number	Keyword	Frequency	centrality	Serial Number	Keyword	Frequency	centrality
1	Rural Teachers	107	0.22	6	Rural revitalization	19	0.1
2	Rural education	52	0.43	7	Rural	16	0.37
3	Internet +	42	0.08	8	Rural schools	15	0.23
4	Professional development	22	0.43	9	Information literacy	14	0.03
5	Artificial intelligence	22	0.27	10	Internet	13	0.08

The cluster quality was evaluated according to the module value (Q) and average contour value (S) provided by CiteSpac. Q 0.3 illustrate clustering structure significantly, and S reaching 0.7 indicates the cluster has a strong degree of tightness and consistency.[7] The data showed that Q=0.8492, S=0.9645, which confirmed the significance and significance of the clustering structure of this study. Further generalization finds that most scholars' discussions revolve around the following three points：technical support, professional development and rural education.
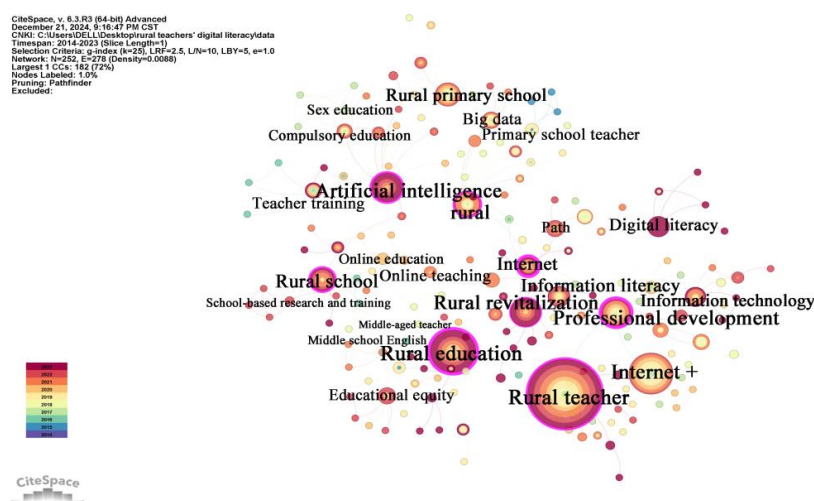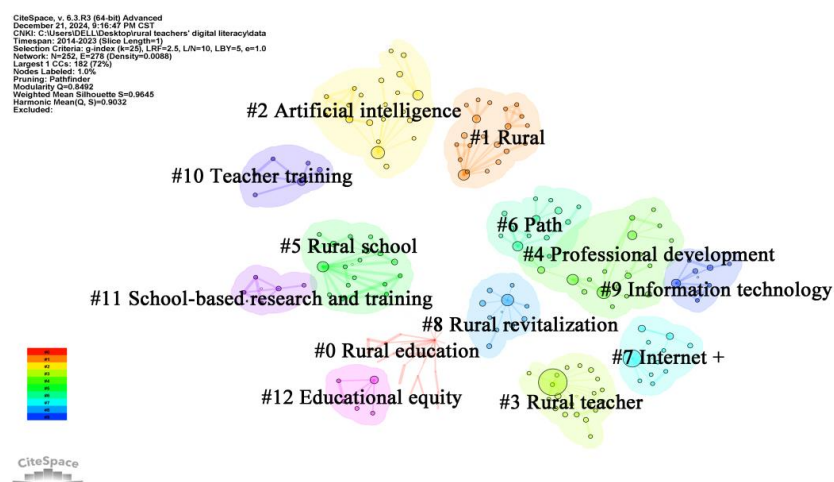

Figure 3. Keywords co-occurrence knowledge graph

Figure 4. Key words clustering atlas

Technical empowerment for digital literacy development of rural teachers

Technology upgrading has provided new opportunities for the professional development of rural teachers. Using technology to help rural teachers grow in education and teaching has always been one of the goals of the country and academic circles. Teachers' digital literacy is the sensitivity and ability that teachers should have by properly using digital technology, through collecting, selecting, organizing and evaluating digital information and resources, effectively analyzing and solving education and teaching problems, and constantly enriching and optimizing education and teaching activities. According to the different characteristics of the integration of technology and rural teachers' teaching, the development process is summarized into three stages: computer aided, "Internet plus" and "artificial intelligence plus". These three stages are overlapping development processes. Today, it is imminent and critical to enhance rural teachers' ability of technology-Driven application.[8] Teachers carry out large-scale personalized education with the help of artificial intelligence, provide timely and professional learning feedback to students according to their learning portraits, and help students carry out personalized learning.[9]

Data mining and ability improvement of rural teachers

Data mining, resource utilization and skill improvement of rural teachers are the hot topics in the academic circles. First, rural teachers face many difficulties in improving their digital literacy. Data mining and other data thinking is not strong. Informatization education management and governance policies are not in place, teachers lack of informatization awareness, psychological anxiety has not been effectively alleviated, informatization teaching and training effects are not good, and teaching resources are difficult to meet the personalized teaching needs.[10] Second, there are differences in different dimensions of digital literacy. Compared with teachers in cities, counties and towns, there are certain gaps in all dimensions of information literacy of rural teachers. The digital environment and literacy, teaching effectiveness and teacher resilience of rural teachers are relatively weak.[11] Some scholars have analyzed and found that rural teachers' information literacy and equipment use status are at an average level on the whole, and there is a certain correlation between school type, age, teaching age, record of formal schooling, Job title and rural teachers' data literacy and facilities use status. [12]

The third is the training suggestions of rural teachers 'digital literacy. For example, reshaping teachers' digital concepts, establishing a digital literacy professional development community, and coordinating multi-party advantages. Some scholars have deeply analyzed a typical case of a middle school in Jilin Province, and discussed the specific practices, and the characteristic mode of "One school leads many schools, and many schools lead the region". [13] Some scholars discussed the case of Ningxia and proposed specific strategies to use intelligent technology to empower rural teachers' professional development.[14]

Currently, the theses on rural teachers' digital literacy mainly focus on the aspects of concept analysis, connotation interpretation and empirical analysis. and the researches on specific county empirical research, teacher data thinking and the depth of information technology and specific disciplines are relatively weak. In addition, existing studies mostly interpret the overall situation of rural teachers' digital literacy from a macro perspective, and there are relatively few achievements in in-depth analysis of the specific situation in each dimension. Therefore, based on the county level, it is particularly vital to understand the more detailed reality of rural teachers' digital literacy, explore the influencing factors, and give accurate suggestions.

Rural teachers' digital literacy and rural education

The frequent occurrence of keywords such as "rural education", "rural schools" and "rural revitalization" reflects the academic circles' elevated attention in the information age. A string of studies have explored the significance of rural teachers' digital literacy to the reform of rural education. With the advent of the negative population growth crisis, the source of students is gradually decreasing, and rural small-scale schools have become the basic type of rural schools. By the end of 2021, the goal of basic education being basically balanced at county level has been achieved, and the gap in basic conditions between urban and rural areas has been narrowing. However, the difference in education level is significant, and rural small-scale schools are still the weakest point in the development of compulsory education in China.[15]Rural basic education in the central-west regions and remote areas is not strong enough. Clarifying the connotation and value of the digital innovation of rural education is an vital premise to promote the development of rural schools.[16]

The enhancing of rural teachers' digital literacy is of great significance to the future training of rural talents, population quality and the digital development of rural education. Focus on the value of intelligent technology, with the help of intelligent technology to improve the multidimensional numerical level of rural teachers and students, and promote rural education digitization.[17] In the digital era, the level of teachers 'digital literacy is closely related to the quality of education. It is of great

value to use digital technology and resources，improve teachers 'data mining and use ability, make up for the shortage of teachers in rural schools, students 'limited personalized learning needs and other shortcomings, and narrow the urban-rural education gap.

Research Frontiers of Rural Teachers' Digital Literacy

Emergent words refer to keywords that have been cited with a sudden increase in a period of time. By analyzing the emergent words in literature, we can analyze the research points that have attracted attention in the research process of rural teachers' digital literacy and predict the academic frontier. With the help of the "outburst word detection" function, the outburst map of the top 10 keywords in outburst intensity from 2014 to 2023 was drawn, as shown in Table 4. Taken together, the frontier key-words in the past ten years can be summarized as follows: high-quality and balance, rural junior high school, and path. It can be expressed as: the path of digital literacy of rural teachers aiming at quality and balance.

Table 4. In the first 10 key words popped up

Serial Number	Key words	Time	burst	Start	Finish	2014 - 2023
1	Primary school teacher	2015	1.17	2015	2019	
2	Teacher training	2016	1.7	2016	2017	
3	Preschool teacher	2016	1.12	2016	2017	
4	Internet +	2016	1.81	2017	2020	
5	Rural primary school	2018	1.76	2018	2020	
6	Teacher	2020	1.56	2020	2021	
7	Online teaching	2020	1.17	2020	2021	
8	path	2017	1.29	2021	2023	
9	high quality balanced	2021	1.15	2021	2023	
10	Rural junior high school	2021	1.15	2021	2023	

Equilibrium of quality

Balanced urban and rural education quality is an important indicator of social development level, and thus become one of the academic research and the government's target of pursuit. In the era of negative population growth, the quality-oriented development of small-scale rural schools has become an important issue in the creating a green basic public education service framework.[17] Due to the profound influence of dual structure, there are noticeable differences in education funds, faculty, curriculum and learning materials. Promoting education equity needs to break the dual structure of urban and rural areas and coordinate development overall.[18] As the core strength of the digital transformation of rural education, teaching staff and numerical literacy are the key factors affecting compulsory education developing in a balanced manner.[19] The information literacy of teachers should be improved from the perspectives of renewing educational concept, learning information technology knowledge and improving the application ability of information technology.[20]

The reformation of technology-enabled forced education has evolved from uneven to balanced, then from balanced to new unbalanced, which is a dynamic process that appears alternately and continues to rise, which needs the continuous attention of the state and academia.

Integration and innovation ability of country educators' digital resources

During the research process of rural teachers' digital literacy , "rural primary school" regularly appeared in 2018-2019. From 2021 to 2023, "rural junior high school teachers' digital literacy" became the focus of scholars' research. Country schools are the frontiers and practice fields. As an essential part of basic education, junior high school education bears the heavy responsibility of educational digital transformation. As practitioners of educational digital transformation, junior high school

educators' digital literacy is the core of educational reform.[21] Junior high school is a pivotal period for the formation of pupils' digital literacy. We should vigorously improve the quality of information technology courses, integrate the raising of digital literacy with subject teaching, and school-based courses, in a multi-pronged manner.[22] In addition, compared with primary school, the curriculum content of junior high school is more complex and abstract, and this teaching demand promotes junior high school teachers to use information technology to assist teaching.[23] At present, the unfair distribution of urban-rural resources, the weak hardware and network infrastructure of rural basic education and the relatively backward teaching management and so on, all of which restrict enhancing digital literacy in the basic education stage.

Roadmaps of rural teachers' digital competence

The outbreak of the new coronavirus in December 2019 and the suspension of classes in the Spring Festival semester in 2020 have started a large-scale online education model across the country, which has also promoted the academic research of online teaching. China's large-scale online education practice is the top-ranked globally social experiment in information-based teaching, which has revolutionary significance in terms of educational informationization.[24] In the context of digital transformation, the route of improving rural teachers' digital competence has attracted the attention of numerous scholars. To enhance the efficiency of digital resource allocation in rural regions. the information behavior should be improved from the aspects of equipment conditions, equipment use efficiency, equipment management and system, and the intelligent technology integration ability of teachers should be enhanced.[25] We will improve the system of teacher training, examination and evaluation（Zhang N., Luo Y.etc.2023）.[26] Establish a digital space for emotional support, establish a precise professional development program, build a "smart hand in hand" learning alliance, improve the intelligent education resource sharing mechanism, and build a digital strong teacher community.[27]

According to the emergence of keywords in recent years, it is found that micro-operations such as the practical development path of rural teachers' digital literacy improvement will be the trend of future research.

RESEARCH INSPIRATION AND FUTURE DIRECTION

Improve Teachers 'Data Mining Ability and Promote High-Quality Balance

The essence of greening is the modernization of people. The basis of individual knowledge construction behavior is the cooperative construction in the current technological environment, and the individual and the surrounding environment form an interdependent co-existence.[28] In data age, teachers' digital literacy is a realistic demand for teachers' literacy in the integration of digital technology and teaching, especially for the role of teachers, which brings unprecedented opportunities and challenges. They are the more important contents in the leapfrog development of technical support, data literacy, teaching resources and teaching methods, and ultimately achieve the green growth of village education.

On the one hand, according to the iceberg model of information technology application ability, future research should pay more attention to the lower layer of the iceberg, that is, pointing to a teaching form of pupils. The improvement of countryside teachers' digital skills aims to transform students' learning mode and cultivate their cognitive thinking ability.[29] According to Bloom's classification of cognitive goals, the teaching application level of information technology is divided into high and low levels.[30] The teaching application of high-level information technology, which highlight the mentor of youngers' high order cognitive thinking ability and the depth fusion of information technology and curriculum, should be the focus of future research. On the other hand, the digital transformation of rural education is not the surface usage in education and teaching, but the comprehensive conformity of IT and education and teaching for the purpose of human evolution, the formation of a new ecology of the education system, the promotion of harmonious development of education, and the realization of education fairness.

Combining Theory with Practice and Strengthening Cooperative Development

The boost of rural instructors' digital literacy is a complex process involving multi-subject participation and multi-factor interaction, and its complexity determines the real statement of rural coaches' cross-cultural competence development process from the overall and non-linear complex thinking.

First, establish a community of researchers and practitioners. Make the most of the role of universities, especially pedagogical university, in theoretical guidance and practical guidance, encourage university to build a long time research community with first-line primary and secondary schools, and create a mutually reinforcing and co-development model between researchers and practitioners. Second, strengthen artificial intelligence education in elementary and middle schools. In China, the "top-down" digital promotion of rural education is easy to form economies of scale.[31] However, it also causes the neglect of

the practical requirements, resulting in supply and demand imbalance and other problems, so it should be accurate research and overall planning.

Innovative Training Models and Prioritize Digital Career Advancement

The number of country educators in China is large, the structure is complex, and the dispersion is wide, which has higher requirements for teacher training. Taking Henan as an example, the study argues that the media literacy of country teachers is typically low. And from a specific dimension, digital social responsibility and application capabilities are weak; From the perspective of different teacher groups, the digital literacy of Ms. is superior to that of Mr.. There are differences in different dimensions in different ages and grades. In terms of academic qualifications, rural teachers are slightly weaker than urban teachers, and their ability to apply information technology is lacking.[22] Only by accurately finding the realistic blocking point can we overcome the realistic limitations, and identify an effective path to improve rural instructors' digital proficiency through innovative training models and accurate training.

First of all, create a hierarchical training course system to meet the needs of different teacher groups. Develop targeted digital resources for teachers with different disciplines, study segments and educational backgrounds, constantly improve the supply-side reform of rural teachers' digital literacy training, and establish a standardized evaluation mechanism.[27] Secondly, establish a training closed loop supported by real data. In teaching and academic research, data on the existing state of rural teachers' digital literacy is constantly collected, and precise training is conducted on the basis of real data analysis to directly target the pain points and difficulties faced by teachers and improve the effectiveness of training. Finally, the training forms should be enriched, focus on digital professional development, and the mode of combining online and offline training should be established to broaden the communication population of the learning community, increase the depth of training, and provide convenience for the instructor's specialized growth.[30]

CONCLUSION

The lift of rural teachers 'digital literacy during the process of accelerated iterative upgrading of information technology is a long-term and dynamic process. In the past decade (2014 to 2023), papers on the enhancement of rural teachers 'digital literacy has yielded fruitful results. Revolve around the goals of rural teachers 'digital specialized training, data thinking, high-quality balance and educational equity, a more specific and actionable path to improve rural teachers 'digital literacy was proposed. Such as teacher-led inquiry, teacher training, network learning, resources adaptation, technical support, data mining and other measures. Meanwhile, it also concerns the construction of digital literacy standards such as information and data literacy of rural teachers. However, the research community is relatively scattered, and the core author group and institutional group have not yet formed. The complexity of the technology-enabled education upgrading and the long-term nature require the majority of front-line educators and scholars to cooperate and explore for a long time to facilitate the multi-dimensional expansion of rural teachers 'digital literacy.

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