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Rural Teachers' Digital Competence: Impediments and Developmental Responses

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Abstract: Digital transformation of education is an inevitable trend in the development of education in the digital era. Teachers' digital competence is the comprehensive ability of teachers to use digital technology to empower the teaching and learning process, which plays an important role in promoting the digital transformation of education, advancing educational equity, and cultivating students' digital competence. Under the dual system of urban and rural areas, there is a gap in digital competence between urban and rural teachers due to factors such as ambiguous cognition of rural teachers' digital technology, insufficient support, and lack of assessment and training systems, which may further widen educational inequality between urban and rural areas. The development of rural teachers' digital competence can be promoted by guiding them to change their way of thinking, increasing support, and improving assessment and training systems.

Keywords: Rural Areas; Rural Teachers; Digital Competence.

1. Introduction

The development of digital technology has profoundly changed people's production and living activities, and promoted the transformation of human society from an information and knowledge society to a digital and intelligent society. How to transform education methods and contents to cultivate digital citizens suitable for digital and intelligent societies is an important issue nowadays. Teachers are the key to the educational process and play an important role in the process of digital transformation of education at the micro level, and are the pioneering force in the cultivation of future social citizens. With this in mind, training teachers with digital competencies has become one of the strategic objectives of digital transformation in many developed countries. The National Digital Competence Plan issued by Spain in 2020 includes teacher digital competence as one of the main strategic objectives [1]; the Digital Education Action Plan 2021-2027 issued by the European Commission in 2020 lists teacher digital competence literacy, training, and the creation of a digital skills certificate common to Europe as an important developmental objective; and the U.S. Department of Education's 2022 Digital Literacy Gas pedal Program" issued by the U.S. Department of Education in 2022 proposes to focus on developing teachers' ability to find, evaluate and deliver online quality information. China has also entered the era of Education Informatization 2.0, and the government has introduced a series of policies and plans aimed at promoting the digital transformation of education and enhancing teachers' digital competence, such as the "Guide to the National Primary and Secondary School Teachers' Information Technology Application Competence Enhancement Project 2.0 School-Based Application Examination Guide" (2021) and the "Teachers' Digital Literacy" (2022), with the aim of taking the world's lead in the process of the digital transformation of education. Under the guidance of social changes and policies, teachers' digital competence has gradually become a hot issue for scholars at home and abroad. Based on the visual analysis of the established literature, it is found that the relevant research mainly focuses on three aspects: first, the conceptual research on teachers' digital competence, including the concepts of digital literacy, digital competence, digital competence, etc.; second, the research on the framework of teachers' digital competence, i.e., the constitutive elements, structure and other issues of teachers' digital competence; and third, the applied research on the framework of teachers' digital competence, which mainly focuses on the use of the framework for the assessment of teachers' digital competence [2]. In terms of research objects, scholars have focused on subgroups such as pre-service teachers and higher education teachers, and have paid insufficient attention to subgroups such as basic education teachers and rural teachers.

Rural teachers are the key force in the digital transformation of education in rural areas [3]. An important reason for the current "digital divide" in education between urban and rural areas in China and the new educational inequality problems brought about by it lies in the gap in teachers' digital competence between urban and rural areas. The study of Lu Chun and Xing Danxia pointed out that there is a big gap between urban and rural teachers in terms of digital technology accessibility, digital awareness, and digital technology use ability [4]. Yang Lei and Zhu Dequan found that there is also a significant difference between urban and rural teachers' informatization learning power based on questionnaire data [5]. The gap between urban and rural teachers in digital competence and learning power may widen the gap between urban and rural education to a certain extent, causing new inequality between urban and rural education. By the end of 2021, there are still 28.57 million compulsory education students in rural areas attending primary and secondary schools in China, accounting for 18.1% of the number of students enrolled in compulsory education. These students may face new educational inequalities due to the gap between urban and rural teachers in terms of digital competence. Therefore, improving the digital competence of rural teachers is of great practical significance for promoting the digital transformation of education in rural areas, enhancing the quality of teaching in rural areas, guaranteeing rural students' access to quality educational resources, and thus narrowing the gap between urban and rural education and promoting educational equity.

Based on the above analysis, this paper takes rural teachers as the research object, uses China Knowledge Network as the main database, draws on the two-level barrier framework for teachers' technology integration proposed by Ertmer et al. in 2012 [6], focuses on the analysis of obstacles to the development of rural teachers' digital competence, and puts forward countermeasure suggestions, with a view to promoting the development of teachers' digital competence in rural areas, thereby realizing the improvement of education quality in rural areas and narrowing the education gap between urban and rural areas.

2. Teachers' Digital Competencies: Comprehensive Competencies Necessary for Teachers in the Digital Age

Digital competence is one of the key skills that citizens, especially teachers, must acquire in the future society [7]. The European Commission defines digital competence as the ability to use digital technologies safely, critically, and responsibly in learning, work, and social participation, including five Level 1 competencies and 21 Level 2 competencies in data processing, digital content creation, communication and collaboration, problem solving, and security [8]. Teachers' digital competence is the digital competence that teachers should possess, which has the universality of citizens' digital competence and contains the specificity of the teaching profession. Krumsvik et al. consider teachers' digital competence as a system of competence in which teachers are proficient in the use of ICT in a professional context, have good pedagogical judgments, and are aware of their impact on the development of students' learning strategies and learning abilities [9]. According to Zheng Xudong, teachers' digital competence is a cluster of competence traits that teachers have that can facilitate their productive application of digital technology to carry out teaching activities and achieve teaching goals [10]. Comparing the definitions of scholars at home and abroad, it can be found that teachers' digital competence is actually the ability of teachers to utilize digital technology to empower the teaching process, which is the product of the combination of digital technology and teachers' professional competence, and it is a kind of comprehensive competence that must be mastered by teachers in the digital era. In view of the multi-dimensional, complex and comprehensive characteristics of teachers' digital competence, many organizations and scholars have constructed frameworks for teachers' digital competence, and Qiu Xiaochun et al. classify these frameworks into conceptual frameworks and content-based frameworks (including inventory-based frameworks and developmental frameworks) according to their contents [11], and Table 1 lists representative frameworks of each category and their main contents.

Table 1. Digital Competency Framework for Representative Teachers and its Classification

Classification of frames	Representative framework	Main content
Conceptual framework	A Framework of Knowledge for Subject Matter Teaching and Learning that Integrates Technology (2006)	Integrating content knowledge, pedagogical knowledge, and technological knowledge into seven knowledge domains provides a program that can be built upon to facilitate technology-integrated classrooms.
Inventory-based framework	Educator Standards of the American Society for Technology in Education International (2017)	Suggests seven roles for teachers in the digital age: learner, leader, citizen, collaborator, designer, facilitator, and analyzer, each of which represents a different set of competencies.
	China Digital Literacy for Teachers (2022)	Teachers' digital literacy was categorized into five dimensions: digital awareness, digital technology knowledge and skills, digital applications, digital social responsibility, and professional development.
Development-oriented frameworks	EU Digital Competency Framework for Educators (2017)	Teachers' digital competencies are categorized into six dimensions: professional engagement, digital resources, teaching and learning, assessment, empowering learners, and enhancing learners' digital competencies. In addition, the development of teachers' digital competence is designated as six levels: novice, explorer, synthesizer, expert, leader, and trailblazer, providing standards for the assessment and development of teachers' digital competence.
	UNESCO ICT Competency Framework for Teachers (2018)	Divide teacher digital competencies into six areas: understanding IT educational application policies, curriculum and assessment, teaching methods, digital technology application, organization and management, and teacher professional learning. Teachers' digital competence was divided into three successive stages of development: knowledge acquisition, knowledge deepening and knowledge creation.

Based on the above analysis of teachers' digital competence and its framework, this paper argues that teachers' digital competence is a comprehensive competence that teachers must possess in the digital era, which can be divided into basic digital competence and pedagogical digital competence. Basic digital competence is the digital competence that teachers should have as a social public, the ability to use digital technology safely, critically and responsibly as an individual to participate in social activities, and the basis of teachers' pedagogical digital competence. Pedagogical digital competence is the ability of teachers to effectively integrate digital technologies into the classroom teaching process, including selection competence (the ability to recognize the value of digital technologies in pedagogical applications and to judge when and where it is appropriate to use digital technologies for teaching), pedagogical competence (i.e., the ability to use digital technologies to prepare for and conduct lessons; the ability to use digital technologies to create

pedagogical content and innovate curriculum design), management competence (i.e. ability to utilize digital technology for classroom management, student evaluation, etc.), and reflective ability (i.e., the ability to reflect on the application of digital technology in teaching and classroom management).

In the context of the era of digital transformation of education, it is of great significance to improve teachers' digital competence, especially rural teachers' digital competence: from a macro point of view, improving teachers' digital competence is conducive to narrowing the problems of educational inequality between urban and rural areas and between regions; from a meso point of view, teachers' digital competence is conducive to improving the quality of teaching in schools and school management; from a micro point of view, teachers' digital competence has a positive contribution to their own From a micro point of view, the improvement of teachers' digital competence has a positive effect on their own professional development, and is also conducive to improving students' learning experience, stimulating their interest in learning, and thus promoting the cultivation and development of their independent learning and lifelong learning abilities.

3. Impediments to the Development of Rural Teachers' Digital Competence

Ertmer et al. categorized the barriers to technology integration faced by teachers into two groups: primary and secondary barriers. Tier 1 barriers are external barriers faced by teachers, including barriers in the areas of access to digital resources, technology training, and social support; Tier 2 barriers are internal barriers faced by teachers, including teachers' confidence, beliefs, and perceived value of technology [12]. Based on this, this paper categorizes the barriers facing rural teachers' digital capacity development into internal and external barriers: internal barriers refer to rural teachers' ambiguous perceptions of digital technology; and external barriers include insufficient support for rural teachers' digital capacity building, inadequate assessment systems, and lagging training systems.

3.1. Rural Teachers' Vague Perceptions of Digital Technology

Perceptions of digital technology include the following aspects: first, the perception of the value of digital technology applied to the teaching process, i.e., whether digital technology is able to empower and optimize the teaching process; second, the sense of self-efficacy in the application of digital technology, i.e., the self-perception of optimization of the teaching process and improvement of the educational effect brought about by digital technology; and third, the digital mindset, i.e., whether it is possible to change the traditional mindset along with the digital transformation of education. Third, digital thinking, that is, whether to change the traditional way of thinking with the digital transformation of education and form the Internet spirit that includes the spiritual connotation of openness, equality, sharing and creation. Perception of digital technology is an important part of teachers' digital competence, which guides teachers on whether and when to apply digital technology to assist teaching. Some foreign studies have pointed out that teachers' positive attitudes, beliefs, and self-efficacy toward digital technology can positively predict teachers' digital competence [13]. From the practical point of view in China, there are ambiguities in rural teachers' understanding of digital technology: firstly, from the point of view of value judgment, the teacher community generally has a positive attitude towards the value of digital technology in the teaching process, i.e., they believe that digital technology is able to empower and optimize the process of teaching; secondly, from the point of view of self-efficacy, self-efficacy comes from the successful teaching practice, but in rural areas, the lack of the necessary digital teaching equipments However, the lack of necessary digital teaching equipment and digital educational resources in rural areas has led to a general lack of self-efficacy among rural teachers regarding digital technology, with a survey showing that only 32.5% of teachers believe that digital technology has significantly improved teaching and learning [14]; and lastly, from the viewpoint of digital thinking, the study by Wu Main et al. found that the teacher community's sense of innovation and sharing in the application of digital technology is still deficient [15]. In summary, rural teachers' knowledge and perception of digital technology in teaching and learning applications are still unclear, which hinders the further development of rural teachers' digital competence.

3.2. Insufficient Support for Digital Capacity Development for Rural Teachers

Supporting factors for rural teachers' digital capacity development come from three domains: government, schools and parents. Government refers to the program planning and financial support for teachers' digital capacity development developed by the government; school refers to the attitude of school administrators towards the use of digital technology in the teaching and learning process as well as the provision of digital educational equipment and digital educational resources for teachers; and parent refers to the attitude of students' parents towards teachers' use of digital technology in teaching and learning. The interaction of the three shapes the practice trajectory of rural teachers' digital competence development. However, in terms of the current specific practices in China, the support from all three areas is limited and insufficient to support the continued development of rural teachers' digital competence. From the government's perspective, there is a lack of detail in policy planning and a shortage of financial support. On the one hand, the Ministry of Education (MOE) has formulated a series of policies and programs related to the development of teachers' digital competence since the Teachers' Educational Technology Competence Building Program was launched in 2004, and the industry standard of Teachers' Digital Literacy was introduced in 2022. Although these policies clearly define teachers' digital competence, they lack a detailed plan for building teachers' digital competence. detailed planning for the development of teachers' digital competence, which is not very operable; on the other hand, rural schools receive limited financial support from the government, which restricts the accessibility of digital technology and digital resources to rural teachers and students. From the viewpoint of schools, there are common problems such as insufficient digital education equipment and lack of digital education resources in primary and secondary schools in rural areas [16], the deep-seated reasons for which lie in the limited education funding for schools in rural areas, and the unsound mechanism for sharing high-quality education resources. From the viewpoint of parents, the prejudices of parent groups against digital technology also weaken the motivation of teachers to apply

digital technology, and these prejudices include the physical damage caused by computer equipment, and the belief that teachers' use of digital educational resources is a kind of lazy behavior.

3.3. Lack of a Digital Competency Assessment System for Rural Teachers

Digital competence assessment is an important driving force for the development of teachers' digital competence. Through competency assessment, on the one hand, teachers can know the level of their own digital competency and continuously improve the shortcomings in their subsequent development; on the other hand, the data generated by the assessment can also be used for the evaluation of teachers' titles and the issuance of bonuses, providing teachers with direct external incentives. The Ministry of Education (MOE) released the industry standard of "Teachers' Digital Literacy" on November 30, 2022, which divides teachers' digital literacy into a framework system of 5 first-level dimensions, 13 second-level dimensions, and 33 third-level dimensions, and provides a standard and a basis for the development of an assessment system for teachers' digital competence. However, at present, China has not developed an assessment system specifically for primary and secondary school teachers' digital competence, and there are fewer related studies [17]. It can be said that the assessment system of rural teachers' digital competence is currently in a state of absence, which not only fails to play the role of promoting the assessment system as it should, but also becomes an obstacle to the further development of rural teachers' digital competence.

3.4. Lagging Digital Competency Training System for Rural Teachers

Teacher training is an important way of professional development of teachers. Daan et al. stated that the most effective way to develop teachers' digital competence is to integrate digital technologies into the learning process of teachers and to make it part of their training [18]. Some empirical studies have also shown that the number of trainings and the total number of hours of training that rural teachers attend positively predicts their ability to apply digital educational resources [19]. China attaches great importance to teacher training at the compulsory education stage, and has formed a teacher training system including school-level training, town-level training, county-level training, provincial-level training and national-level training, but there are still several problems in rural teacher training: first, the content of the training mainly focuses on teacher ethics, subject teaching and educational regulations, with insufficient attention paid to the training of digital technologies; second, compared with urban teachers, the Secondly, compared with urban teachers, rural teachers have access to a small number and low quality of training, especially training specifically for digital competence; thirdly, the formalization and flow of training, teacher training is detached from teaching practice, and there is the phenomenon of "capacity building starts with training and stops with training" [20]; fourthly, there is a single training path, with more emphasis on formal training carried out by the school and education authorities, providing teachers with the opportunity to learn about digital technology, and providing teachers with the opportunity to learn about digital technology, as well as the opportunity to learn about digital technology. Fourthly, there is a single training path, with more emphasis on formal training conducted by schools and education authorities, providing teachers with limited professional development paths and ignoring the initiative of teachers in realizing the development of digital competence.

4. Possible Paths to Digital Capacity Building for Rural Teachers

4.1. Guiding Rural Teachers to Change Their Way of Thinking

Perceptions of and attitudes toward digital technology are an important part of teachers' digital competence, both as a starting point for and throughout the development of teachers' digital competence, and ultimately reflecting the maturity of teachers' digital competence. Rural teachers' ambiguous attitudes toward digital technology can be clarified in the following three ways. First, increase the publicity of digital transformation in education and promote rural teachers to establish the correct cognition of digital technology empowering the teaching process. Second, teachers should be given a certain degree of teaching autonomy when teaching goals are set, while teachers should be encouraged to utilize digital educational technologies and digital educational resources to improve their sense of self-efficacy. Finally, attention should be paid to cultivating rural teachers' digital mindset. Critical, sharing and innovative spirit are important components of teachers' digital thinking, and rural teachers should be guided to look critically at the value of digital technology in the educational process and to complement their strengths; a teacher exchange platform should be established to cultivate teachers' sharing thinking and innovative spirit.

4.2. Enhancing External Support for Rural Teachers' Digital Capacity Development

External support for the development of rural teachers' digital competence comes from three aspects, namely, the government, schools and parent groups, and can be promoted from these three aspects respectively. First, from the government side, government policies should combine top-level design and action planning, with both strategic goals and specific implementation paths depicted. The details of the plan can be set according to the level of government. The top-level design of the central government should be guiding and have clear action goals, while the grassroots government should take into account its own reality, and under the guidance of the central government's established goals, make action plans for the development of teachers' digital competence in accordance with local conditions, so as to put the policy goals into practice. Second, from the perspective of schools, the main way to solve the problems faced by schools is to increase funding for compulsory education in rural areas and to break down the barriers that hinder the sharing of quality education resources. Specifically, the first is to tilt compulsory education funding to rural areas, ensure that urban and rural teachers and students enjoy the same funding, update and improve digital education equipment in rural schools, and narrow the hardware gap; the second is to establish and improve digital education resource platforms at the school level, the county level, the municipal level, the provincial level, and the national level, breaking down the barriers that impede the flow of high-quality digital education resources between urban and rural areas and between regions, so that schools in rural areas can have access to more and better quality education resources and narrow the software

gap. quality educational resources and narrow the software gap. Finally, from the point of view of parents, on the one hand, parents should be guided to change their stereotypical impression of cell phones, the Internet and so on, and set up a correct cognition of digital technology; on the other hand, we should further promote the collaboration between home and school, in terms of the use of digital technology, parents should take on the responsibility of guiding their children to use digital technology correctly, and at the same time, through the communication and exchanges with teachers and schools, and the cooperation between multiple parties to jointly contribute to the rational and effective application of digital technology in teaching and learning. On the other hand, it is necessary to further promote the collaboration between home and school in the use of digital technology.

4.3. Improvement of Digital Competence Certification and Assessment System for Rural Teachers

Improving the certification and assessment system of rural teachers' digital competence is not only conducive to understanding the current status of their digital competence, but also can indicate the future development direction of their digital competence. Firstly, it is necessary to establish rural teachers' digital competence standards [21], which can draw on the digital competence frameworks for teachers of the European Union, the U.S. International Society for Technology in Education and the United Nations Educational, Scientific and Cultural Organization (UNESCO), and formulate digital competence standards in the light of local realities as the basis for the certification and assessment of teachers' digital competence. Secondly, improve the assessment system of teachers' digital competence, combine digital competence measurement, digital competence assessment and digital competence training, give full play to the role of assessment as a carrier, and provide data support for the development of high-quality digital competence training. Finally, establish a micro-certification system for teachers' digital competence. Micro-certification is a practice-oriented way of evaluating teachers' digital competence, and the results of certification can be displayed in online academic communities, so it can stimulate teachers' intrinsic motivation to develop digital competence [22]. The micro-certification system consists of the publisher (the subject of certification), the owner (the person requesting certification, mainly the teacher community) and the recognizer (the domain that recognizes the value of certification), and in our country, the role of the publisher can be assumed by the universities that have obtained the authorization of the educational management department, while the role of the recognizer can be assumed by the government. In this way, micro-certification is both authoritative and has a solid value base that can stimulate teachers' endogenous motivation to develop digital competence.

4.4. Improving the Digital Competence Training System for Rural Teachers

Training is an important vehicle for improving the digital competence of in-service teachers. In order to improve the digital competence of rural teachers, the digital competence training system for rural teachers can be further improved in the following four aspects. First, the training content should be updated to include digital competence in teacher training. We can learn from the course content system of "Modern Educational Technology Application" developed by Yang Jiumin and other scholars, which is divided into six topics, including theoretical and practical courses, covering all aspects of teachers' digital competence building [23]. Although the curriculum is designed for pre-service teachers, the corresponding modules can be selected according to the training needs of in-service teachers to enhance their digital competence in a targeted manner. Second, the number of trainings should be increased, and more special trainings for rural teachers in backward areas should be carried out to enhance the accessibility of digital competence training for rural teachers. Third, improve the quality of training by combining the assessment of teachers' digital competence with training, so that training demand and training supply correspond to each other, and the pertinence and effectiveness of training can be improved; in addition, virtual reality technology can be used to simulate actual classroom environments, so as to improve the quality of teacher training. Fourth, develop multiple training pathways, give full play to the connectivity of modern information technology, and develop catechism platforms, online learning groups, online teacher communities, etc., so as to provide diversified channels for the development of rural teachers' digital competence. Fifth, improve the training assessment system to ensure the effectiveness of training.

5. Summary

The digital transformation of education is the process of digital technology-enabled education and the deep integration of education and digital technology, and it is an inevitable trend in the development of education in the digital era. Teachers' digital competence is a comprehensive ability necessary for teachers in the digital era, and is of great significance in promoting the digital transformation of education, promoting educational equity and training future social citizens. Under the dual system of urban and rural areas, there are many obstacles to the development of rural teachers' digital competence compared with urban teachers. Drawing on the two-tiered framework of barriers to teachers' technology integration proposed by Ertmer et al. in 2012, this paper categorizes these factors into two groups, internal and external impediments, specifically including rural teachers' ambiguous perceptions of digital technology, insufficient support, and inadequate assessment and training systems. These factors are intertwined and hinder the further development of rural teachers' digital competence. In view of this, this paper proposes relevant countermeasures from four aspects: changing the way of thinking, strengthening the construction of the support system, and improving the assessment and training system, with a view to promoting the development of rural teachers' digital competence, and thus narrowing the urban-rural education gap.

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