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Investigation and Research on Digital Literacy of Rural Teachers in Northwest Guangdong under the Background of Educational Digital Transformation

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Abstract: In the context of educational digital transformation, rural teachers 'digital literacy serves as a critical factor in narrowing urban-rural educational disparities. Based on the Ministry of Education's "Teacher Digital Literacy" standards, this study conducted questionnaire surveys and in-depth analyses with 150 rural primary and secondary school teachers in northwestern Guangdong Province. Results reveal that rural teachers in this region currently exhibit a developmental pattern characterized by "initial formation of core competencies but overall low proficiency levels," manifested through weak digital awareness and social responsibility, skill gaps where "a minority leads while the majority lags behind," superficial application behaviors, and low integration of digital practices. Additionally, structural disparities such as inadequate professional support systems and gender differences remain significant challenges. To address these issues, the study proposes a progressive improvement strategy focusing on "targeted problem-solving and foundational strengthening." This systematic approach encompasses six dimensions: consolidating core competencies, bridging capability gaps, promoting deep digital application, enhancing responsibility awareness, optimizing support systems, and activating collaborative group efforts, aiming to facilitate digital transformation in rural education.

Keywords: Digital Education; Rural Teachers; Digital Literacy; Current Situation Survey; Improvement Pathways

1. Introduction

China explicitly outlined in 2022 the goal of "promoting educational digitalization and building a learning society for lifelong education and a learning-oriented nation," providing fundamental guidance for digital transformation in education. In this context, teachers—as practitioners of educational reform and core forces in talent cultivation—have seen their digital literacy become a critical pillar driving educational digitalization. Digital transformation in education serves as a vital pathway for high-quality development of rural teaching teams. By leveraging digital tools to upgrade infrastructure and facilitate resource sharing, we can achieve foundational improvements in rural teacher education systems and equitable distribution of quality teaching resources [1]. Research further emphasizes that digital technology empowerment and resource platform development constitute educational solutions for urban-rural equity challenges in the digital era. Enhancing rural teachers 'digital literacy directly impacts cross-regional access to quality resources and the cultivation of digital talent, offering breakthroughs for balanced urban-rural education development [2]. Improving rural teachers' digital teaching capabilities not only responds proactively to China's modernization of rural education but also aligns with global trends in educational digital transformation [3]. However, rural education remains a digital underdeveloped area. Compared to urban regions, rural teachers face challenges such as inadequate professional training, limited digital resources, and weak technical application skills [4], with their digital literacy levels significantly influencing urban-rural educational equity and modernization progress. Therefore, implementing educational digitalization strategies and comprehensively enhancing rural teachers' digital literacy are essential requirements for narrowing educational disparities and advancing national education development goals.

2. Questionnaire Design

This study focuses on rural teachers in northwestern Guangdong Province as the survey subjects. Based on the integration of policy standards and regional characteristics, and referencing the questionnaire framework developed by academic scholars, we systematically designed a digital literacy survey questionnaire to ensure the scientific validity and relevance of the data.

2.1. Basis for Questionnaire Design

The questionnaire design primarily references two core frameworks: First, the "Teacher Digital Literacy" industry standard issued by China's Ministry of Education in 2022, which defines five key dimensions—digital awareness, digital technology knowledge and skills, digital application proficiency, digital social responsibility, and professional development. Second, the questionnaire framework developed by Wang Jiale from Hebei University of Economics and Business for rural primary and secondary school teachers, encompassing five dimensions such as digital awareness and digital teaching application capabilities [5]. Considering the prominent collaborative needs of rural teachers in northwestern Guangdong, the final questionnaire was structured around five evaluation dimensions: digital awareness, digital knowledge and skills, digital teaching application proficiency, digital security, and digital professional development capabilities.

2.2. Questionnaire Structure and Scoring Methodology

The questionnaire comprises two modules: Basic Information and Digital Literacy Assessment. The Digital Literacy Assessment module consists of five dimensions, with question formats and scoring criteria as follows: 1) Digital Awareness, 2) Digital Technology Knowledge and Skills, and 3) Digital Social Responsibility are assessed using a five-point Likert scale (from "completely disagree" to "completely agree"), with scores ranging from 1 to 5. Higher scores indicate greater proficiency in each dimension. 4) Digital Application is evaluated through multiple-choice questions (0/1 scoring system), where selected options receive 1 point and unselected options receive 0 points, with higher scores reflecting more extensive digital application practices. 5) Digital Professional Development is measured through frequency questions (from "never" to "always"), assigned 1 to 5 points, where higher scores indicate increased frequency of professional development activities. Scores across dimensions can be analyzed individually or aggregated to form a comprehensive evaluation metric for teachers' digital literacy.

2.3 Validity and Reliability Testing

2.3.1 Reliability testing

Exploratory factor analysis was employed to assess the structural validity of the questionnaire, with KMO and Bartlett's test results presented in Table 1.

The core function of reliability analysis lies in assessing the consistency and stability of questionnaire data across different time periods and contexts, thereby determining whether measurement tools truly reflect the constructs being measured rather than random errors. In social science research, Cronbach's α coefficient is widely regarded as the gold standard for evaluating internal consistency: scales with $\alpha \geq 0.9$ are considered to have "excellent" reliability. When sample size meets the empirical rule of "number of items × 10," sampling errors further reducing reliability estimates can be minimized. Since reliability testing is applicable only to Likert scale items, mixed-dimensional questionnaires containing multiple-choice and single-choice items cannot directly calculate α coefficients, as such results would be invalid. This questionnaire consists of two components: the first part comprises factual single-choice and multiple-choice items designed to collect objective information, making internal consistency reliability testing inapplicable; the second part contains Likert scale items for measuring attitude tendencies. Therefore, reliability testing is conducted solely for the second component (Cronbach's α coefficient), while overall questionnaire validity is ensured through expert review and content validity. Consequently, reliability testing serves not only as a "quality threshold" for research but also as a critical prerequisite for enhancing academic credibility and facilitating the translation of research findings into practical applications.

This study conducted systematic reliability testing of the "Digital Literacy Scale for Rural Teachers in Northwest Guangdong" using 150 valid questionnaires as analytical units. Cronbach's α coefficients were employed to assess questionnaire reliability. Since reliability testing is only applicable to Likert scale items,

mixed dimensions containing multiple-choice and single-choice questions cannot directly calculate α coefficients, as such results would be invalid. Dimensions 3 (Digital Application) included multiple-choice items, while Dimension 5 (Professional Development) contained both single-choice and multiple-choice items. Therefore, reliability testing was performed exclusively on Dimensions 1, 2, and 4, as well as the total questionnaire (scale item section), with Dimensions 3 and 5 treated as dummy variables. Results showed that all dimension α coefficients ranged between 0.70 and 0.92, with the three-dimensional α coefficient reaching 0.832—all values exceeding 0.70, indicating good questionnaire reliability.

Table 1. KMO and Bartlett's Test

dimension	General questionnaire (scale section items)	Digital awareness	Digital knowledge and skills	digital liability
Clonal Bach Alpha	0.832	0.703	0.926	0.721
number of terms	8	2	4	2

In summary, the scale demonstrated nearly perfect internal consistency and stability among rural teachers in northwestern Guangdong, providing a robust and reliable data foundation for subsequent status assessment, difference testing, and intervention strategy development.

2.3.2 Validity testing

To ensure the scale's accuracy in measuring the theoretical construct of "Digital Literacy Among Rural Teachers in Northwest Guangdong," this study employed the KMO sample adequacy test and Bartlett's sphericity test for data validity assessment. The KMO value evaluates partial correlations between variables, with values closer to 1 indicating suitability for factor analysis. The Bartlett test determines whether the correlation coefficient matrix significantly deviates from the identity matrix, thereby validating the common factor structure among variables.

Table 2. Validity Analysis Using KMO Test and Bartlett's Test

KMO sample adequacy statistic		0.84
Bartlett sphericity test	Approximate chi-square	656.374
	Degrees of Freedom (df)	36
	conspicuousness (P)	0.000***
Note: ***, **, and * represent significance levels of 1%,5%, and 10%, respectively.		

As shown in Table 2, the KMO value of 0.84 (exceeding the threshold of 0.7) indicates strong partial correlations among variables, confirming suitability for factor analysis. The Bartlett's test yielded an approximate chi-square value of 656.374 (with 36 degrees of freedom), corresponding to a significant p-value of 0.000 at the 1% level, which rejects the null hypothesis of no inter-variable correlations and further validates the prerequisites for factor analysis. Collectively, these findings demonstrate high structural validity in the current variable system, making dimensionality reduction methods appropriate for extracting common factors.

2.3.3 Structural validity testing – exploratory factor analysis

Table 3. Coefficient of Correlation Table

	Digital Application Scope	Perceptual disturbance intensity	Mean values of three dimensions of core competencies
Digital Application Scope	1(0.000***)	0.469(0.000***)	-0.065(0.430)
Perceptual disturbance intensity	0.469(0.000***)	1(0.000***)	-0.086(0.296)
Mean values of three dimensions of core competencies	-0.065(0.430)	-0.086(0.296)	1(0.000***)
Note: ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.			

To assess the validity of converting multiple-choice questions into variables (digital application breadth and perceived disability intensity), Pearson correlation analysis was employed. The results (see Table 3) demonstrated a significant positive correlation between digital application breadth and perceived disability intensity ($r=0.469$, $p<0.001$), indicating a moderate synergistic relationship between the two variables. The mean scores of

the three core competency dimensions showed no significant correlations with digital application breadth (r=-0.065, p=0.430) or perceived disability intensity (r=-0.086, p=0.296), suggesting relatively independent developmental trajectories of core competencies. All autocorrelation tests for the three variables reached statistical significance (p<0.001), confirming the reliability of the measurement tool.

To further validate the latent structure of the "Digital Literacy Scale for Rural Teachers in Northwest Guangdong," this study employed principal component analysis for exploratory factor analysis. The results demonstrated a KMO value of 0.84 and a Bartlett's sphericity test p-value <0.001, identifying four factors with eigenvalues greater than 1, which collectively accounted for 74.42% of total variance. After rotation, the factor contribution rates became more balanced (31.59%, 15.03%, 14.31%, and 13.49%), indicating a clear factor structure and strong structural validity of the questionnaire.

Table 4. Exploratory Factor Analysis

Total variance explained						
ingredient	rotational forward difference explanation rate			variance explained after rotation		
	characteristic root	Variance explained (%):	Cumulative variance explained (%):	characteristic root	Variance explained (%):	Cumulative variance explained (%):
1	4.174	37.944	37.944	347.49	31.59	31.59
2	1.625	14.777	52.721	165.332	15.03	46.62
3	1.372	12.47	65.191	157.385	14.308	60.928
4	1.015	9.226	74.417	148.379	13.489	74.417
5	0.757	6.879	81.296			
6	0.51	4.64	85.936			
7	0.476	4.324	90.26			
8	0.381	3.468	93.727			
9	0.269	2.447	96.175			
10	0.228	2.069	98.244			
11	0.193	1.756	100			

As shown in Table 4, the four extracted common factors collectively account for 74.42% of the total variance, with a KMO value of 0.84 and a Bartlett's test p-value <0.001. The rotated factor structure demonstrates balanced clarity, indicating strong structural validity and criterion-related validity of the questionnaire, thereby establishing a solid foundation for subsequent confirmatory factor analysis.

2.4 Investigation Implementation

The study targeted rural primary and secondary school teachers in multiple areas of northwestern Guangdong Province, including Zhaoqing City, Deqing County, and Huaiji County in Yunfu City. A total of 166 questionnaires were distributed, with 150 valid responses collected, yielding a 90.4% response rate. This high recovery rate was attributed to well-organized procedures and strong teacher participation. The majority of invalid responses resulted from responses completed within 50 seconds or containing logical inconsistencies. Statistical analysis of the data was conducted using SPSS PRO software, providing reliable evidence for subsequent research on current conditions and underlying causes.

3. Investigation Data and Analysis of Current Status Causes

3.1 General Correlation Analysis of Questionnaire Items

The correlation analysis results are presented in Table 5. Digital awareness, digital technology knowledge and skills, and digital social responsibility exhibited significant positive correlations (r ranging from 0.264 to 0.384, p <0.01), indicating that these three factors collectively constitute the core internal structure of teachers 'digital literacy. Application frequency showed significant positive correlations with each dimension of core competencies (r ranging from 0.262 to 0.421, p <0.01), while application breadth demonstrated no significant association with core competencies (|r| <0.05, p> 0.05). Perceived barrier intensity was only significantly positively

correlated with application breadth (r = 0.469, p <0.01) and showed no significant relationship with other core competency dimensions. Training experience and skills (r = 0.264, p <0.01) as well as responsibility (r = 0.253, p <0.01) exhibited significant positive correlations. These findings indicate that the core dimensions of teachers' digital literacy (awareness, skills, and responsibility) demonstrate strong internal consistency, whereas application breadth and perceived barrier intensity exhibit relatively independent relationships, which will be considered as separate factors in subsequent analyses.

Table 5. Results of Correlation Analysis between Different Dimensions

	Digital awareness	Knowledge and Skills in Digital Technology	Application frequency	Digital Application Scope	Digital Social Responsibility	training record	Perceptual disturbance intensity
Digital awareness	1(0.000***)	0.264(0.001***)	0.262(0.001***)	-0.079(0.334)	0.326(0.000***)	0.146(0.075*)	-0.034(0.683)
Knowledge and Skills in Digital Technology	0.264(0.001***)	1(0.000***)	0.421(0.000***)	-0.001(0.994)	0.384(0.000***)	0.264(0.001***)	-0.051(0.534)
Application frequency	0.262(0.001***)	0.421(0.000***)	1(0.000***)	-0.133(0.104)	0.335(0.000***)	0.146(0.074*)	-0.032(0.698)
Digital Application Scope	-0.079(0.334)	-0.001(0.994)	-0.133(0.104)	1(0.000***)	-0.081(0.321)	0.004(0.964)	0.469(0.000***)
Digital Social Responsibility	0.326(0.000***)	0.384(0.000***)	0.335(0.000***)	-0.081(0.321)	1(0.000***)	0.253(0.002***)	-0.107(0.192)
training record	0.146(0.075*)	0.264(0.001***)	0.146(0.074*)	0.004(0.964)	0.253(0.002***)	1(0.000***)	0.036(0.664)
Perceptual disturbance intensity	-0.034(0.683)	-0.051(0.534)	-0.032(0.698)	0.469(0.000***)	-0.107(0.192)	0.036(0.664)	1(0.000***)
Note: ***, **, and * represent significance levels of 1%,5%, and 10%, respectively.							

Table 6. Linear-Regression Analysis

Results of linear regression analysis n=150									
	nonstandardized coefficient		standardization coefficient	t	P	VIF	R^2	adjust R^2	F
	B	standard error	Beta						
constant	0.911	0.262	-	3.472	0.001***	-	0.293	0.258	F=8.401 P=0.000***
Q1_Gender	-0.04	0.088	-0.033	-0.457	0.648	1.057			
Q2_Teaching Experience	-0.039	0.042	-0.067	-0.915	0.362	1.092			
Q3_Type of School	0.052	0.053	0.075	0.986	0.326	1.156			
Application frequency	0.353	0.058	0.447	6.067	0.000***	1.091			
Digital Application Scope	0.026	0.049	0.042	0.518	0.605	1.311			
training record	0.323	0.093	0.25	3.475	0.001***	1.038			
Perceptual disturbance intensity	-0.043	0.033	-0.108	-1.324	0.188	1.342			
Dependent variable: Mean values of the three dimensions of core competencies									
Note: ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.									

The regression analysis results are presented in Table 6. The model was statistically significant overall (F=8.401, p<0.001), with an adjusted R^2 of 0.258 indicating that independent variables explained 25.8% of the variance in core competencies. Application frequency (β=0.447, p<0.001) and training experience (β=0.250, p=0.001) demonstrated significant positive predictive effects on core competencies, with application frequency exhibiting the strongest explanatory power. In contrast, perceived barrier intensity (β=-0.108, p=0.188), digital application breadth (β=0.042, p=0.605), and demographic variables failed to reach statistical significance. These findings demonstrate that the key determinants of rural teachers' core digital literacy are not tool diversity (breadth) or perceived barriers, but rather application depth (frequency) and external training support, further validating the competency development principle that "depth outweighs breadth."

3.2 Descriptive Statistics and Frequency Analysis of the Questionnaire

3.2.1 Analysis of Teachers' Basic Information

Table 7. Descriptive analysis

name	option	frequency	percentage (%)	Cumulative percentage (%)
Q1_Gender	man	40	26.667	26.667
	woman	110	73.333	100
amount to		150	100.000	100.000
Q2_Teaching Experience	5 years or less	96	64	64

	6-10 years	23	15.333	79.333
	11-20 years	23	15.333	94.667
	21 years and above	8	5.333	100
amount to		150	100.000	100.000
Q3_Type of School	primary school	77	51.333	51.333
	middle school	45	30	81.333
	senior middle school	28	18.667	100
amount to		150	100.000	100.000

As shown in Table 7, the sample characteristics reveal that among the 150 rural teachers surveyed, females constituted 73.333% of the sample. Most teachers had teaching experience of five years or less, with school types predominantly consisting of primary and junior high schools. The teaching experience variable exhibited a right-skewed distribution, indicating a youth-dominated workforce composition. The gender variable displayed a left-skewed distribution, aligning with the actual gender ratio imbalance of "more women than men" in rural teacher populations. The high coefficient of variation for school type categories reflected a relatively dispersed distribution between primary and junior high schools. Overall, the sample structure closely mirrors the actual composition of rural teaching teams. However, all variables exhibited varying degrees of non-normal distribution characteristics, necessitating careful consideration of distribution patterns when applying parameter testing methods for statistical inference.

3.2.2 Descriptive Analysis of Overall Level of Digital Literacy among Rural Teachers

Table 8. Descriptive Analysis of Overall Level of Digital Literacy among Rural Teachers

variable name	Sample size	crest value	least value	average value	standard error	median	variance	Peakness	skewness	coefficient of variation (CV)
Digital awareness	150	3.5	1	1.623	0.602	1.5	0.362	0.345	0.753	0.371
Knowledge and Skills in Digital Technology	150	5	1	2.168	0.867	2	0.752	1.369	0.82	0.4
Application frequency	150	4	1	1.813	0.679	2	0.462	0.25	0.51	0.375
Digital Application Scope	150	3	1	1.933	0.88	2	0.774	-1.704	0.131	0.455
Digital Social Responsibility	150	4.5	1	1.763	0.69	1.5	0.475	1.033	0.963	0.391
training record	150	2	1	1.22	0.416	1	0.173	-0.137	1.366	0.341
Perceptual disturbance intensity	150	5	1	2.273	1.346	2	1.811	-0.498	0.828	0.592

Descriptive statistical results (Table 8) reveal that the distribution patterns and concentration trends of seven variables reflect the complex reality of digital literacy among rural teachers. International studies consistently highlight significant "knowledge-action gaps" and "technology application disparities" in rural educators—while teachers demonstrate positive attitudes toward digital technologies, their practical usage remains at intermediate-to-low levels with heavy reliance on basic tools[6]. Our research identifies a phased characteristic in rural teachers from northwestern Guangdong: "initially formed core structures but overall low proficiency." Specifically, both digital awareness and digital social responsibility exhibit low mean values with right-skewed distributions, indicating that most teachers 'recognition of digital technology value and safety responsibilities remains at foundational stages. The greatest dispersion and maximum range values in digital knowledge and skills demonstrate significant skill differentiation, reflecting a "minority leadership, majority lagging" gap phenomenon. Application frequency distribution shows relative concentration, reflecting limited usage frequency and non-regularized teaching practices. Digital application breadth displays flat distribution with high coefficient of variation, indicating notable disparities in teachers' experimentation with diverse teaching activities—some possess exploratory awareness but lack widespread adoption. Training experience shows extreme right skew, with the majority of teachers having participated in no relevant training programs within three years. This aligns with high dispersion in perceived barriers intensity, suggesting that resource constraints and individualized barriers to perceived challenges jointly constrain literacy improvement. Overall, rural teachers' digital literacy exhibits phased characteristics including "initial formation of awareness and responsibility but generally low levels, significant skill differentiation, limited application depth with uneven breadth of exploration, and severe inadequacy in training coverage." There is an urgent need for tiered

training and targeted support tailored to different groups.

The questionnaire on the current status of digital literacy among rural teachers, as shown in Table 8, analyzes the digital literacy status of rural primary school teachers across six dimensions. Descriptive analysis of their digital literacy levels reveals the following findings:

(1) The mean score for digital literacy awareness was 1.623±0.602, indicating an overall low level with a right-skewed distribution. This suggests that most teachers 'recognition of digital technology's value and willingness to adopt it remain at an initial stage, with only a minority demonstrating strong digital awareness. These findings reveal that rural teachers have yet to develop widespread conscious digital education concepts, show insufficient attention to evolving trends and cutting-edge directions in digital teaching, and struggle to integrate digital thinking into daily instructional practices. The internalization of digital literacy remains a critical area requiring improvement.

(2) The mean score for digital technology knowledge and skills dimension was 2.168±0.867, exhibiting the highest dispersion with a coefficient of variation of 0.4. The data displayed significant right-skewed distribution and peak characteristics, indicating a "minority leadership, majority lag" phenomenon in teachers' skill levels. While a small number of educators demonstrate proficiency in operating various digital devices and software, the vast majority remain at basic operational levels with uneven skill proficiency, reflecting an uneven development pattern of digital skills within rural teacher communities.

(3) The mean frequency of digital technology application was 1.813±0.679, exhibiting a relatively concentrated distribution and near-normal distribution pattern. This indicates that rural teachers generally use digital technologies infrequently, as it has not yet become a routine teaching practice. Most educators only employ digital tools during special occasions such as open classes or performance evaluations, while traditional teaching methods remain predominant in daily instruction. Digital teaching has not been fully integrated into rural teachers' daily teaching practices, and the deep integration of digital technologies with classroom teaching still faces practical constraints.

(4) The mean value of digital application breadth was 1.933±0.88, exhibiting a flat distribution with a high coefficient of variation of 0.455, indicating significant disparities among teachers in experimenting with diverse teaching activities. While some educators effectively utilize digital technologies for courseware development, classroom interaction, and assignment design, most remain confined to single application scenarios. This highlights marked divergence in teachers' awareness of digital teaching innovation, with diversified instructional practices yet to achieve widespread adoption.

(5) The mean score of digital social responsibility dimensions was 1.763±0.690, exhibiting the highest right skewness with a skewness coefficient of 0.963. This indicates that most teachers demonstrate insufficient awareness of cybersecurity and information discernment, while only a minority possess strong digital responsibility consciousness. In actual teaching practices, educators tend to focus excessively on instructional content while neglecting guidance and regulation of students' online behaviors. There are evident gaps in digital ethics education, and overall awareness of digital social responsibility requires further enhancement.

(6) The mean training experience score was 1.220±0.415, exhibiting extreme right skewness with a skewness coefficient of 1.366. The vast majority of teachers had not participated in digital technology-related training in the past three years, indicating severe coverage gaps. Perception barriers showed the highest dispersion, with a mean intensity score of 2.273±1.346 and a coefficient of variation of 0.592, reflecting significant disparities in perceived barriers to competency enhancement. Some teachers faced multiple challenges including insufficient equipment, technical difficulties, and time constraints. The lack of training programs and high dispersion in perceived barriers corroborate each other, collectively revealing structural deficiencies in the professional development support system for rural teachers.

Overall, the seven variables exhibited generally low mean values with coefficient of variation ranging from 0.341 to 0.592, indicating that rural teachers' digital literacy demonstrates phased characteristics: "initial formation of awareness and responsibility but overall low levels, significant skill differentiation, limited application depth with uneven exploration

breadth, and severely inadequate training coverage." These findings suggest that rural teachers remain in an adaptation and initial stage under digitalization, having yet to establish systematic, mature, and routine digital literacy frameworks. Significant disparities exist among teacher groups in terms of awareness, skills, application proficiency, and access support, with multidimensional structural constraints hindering literacy enhancement.

3.2.3 Comparative Analysis of Intergroup Differences

This study employed independent samples t-test and one-way ANOVA to analyze differences in digital awareness, digital technology knowledge and skills, digital teaching application capabilities, digital security practices, digital professional development competencies, and digital communication and collaboration abilities among rural primary and secondary school teachers. The results are presented in Table 9.

Table 9. Analysis of Gender Differences across Dimensions

	Q1_Gender (standard deviation)		F	P
	woman	man		
Digital awareness	0.59	0.63	0.05	0.824
Knowledge and Skills in Digital Technology	0.868	0.875	0.062	0.804
Application frequency	0.626	0.81	3.016	0.085*
Digital Application Scope	0.878	0.87	0.101	0.751
Digital Social Responsibility	0.587	0.897	11.697	0.001***
training record	0.409	0.439	1.059	0.305
Perceptual disturbance intensity	1.37	1.215	2.569	0.111
Note: ***, **, and * represent significance levels of 1%, 5%, and 10%, respectively.				

The independent samples t-test results showed no significant differences between male and female teachers in five variables: digital awareness, digital technology knowledge and skills, application frequency, digital application breadth, and training experience (all $p>0.05$), indicating negligible gender effects on these dimensions. However, significant gender differences were observed in the digital social responsibility dimension ($t=-2.02$, $p=0.045$), with male teachers scoring significantly higher ($M=1.95\pm0.897$ vs. $M=1.695\pm0.587$; $d=0.373$, moderate effect size). Similarly, the perceived barriers intensity dimension exhibited significant gender differences ($t=2.072$, $p=0.040$), where female teachers reported higher perceived barriers ($M=2.409\pm1.37$ vs. $M=1.9\pm1.215$; $d=0.382$, statistically significant).

The independent sample t-test results indicate that male and female teachers show no significant differences in most dimensions of digital literacy, but exhibit marked disparities in two key aspects: digital social responsibility and perceived barriers to digital literacy. Male teachers scored significantly higher than their female counterparts in digital social responsibility, reflecting stronger accountability in guiding students on cybersecurity practices, information discernment, and copyright compliance. Conversely, female teachers demonstrated significantly higher scores in perceived barriers to digital literacy, suggesting they face more pronounced challenges in skill development due to practical constraints such as limited equipment availability, technical difficulties, and time constraints.

Female teachers demonstrate distinctive digital development characteristics marked by "high perceived competence and strong resilience." Despite facing greater practical challenges, they maintain parity with male educators in core dimensions including digital awareness, skill proficiency, application frequency, and scope of implementation, without showing inferior competency levels despite heightened perceived barriers. This phenomenon highlights female teachers 'exceptional adaptability and stress resilience in digital teaching practices, enabling them to proactively address challenges and seek breakthroughs under resource-constrained conditions. Meanwhile, male teachers' relative advantage in digital social responsibility awareness provides crucial support for rural schools in conducting cybersecurity education and information ethics guidance. Overall, gender disparities in digital literacy among rural teachers primarily manifest as structural differences in responsibility awareness and perceived barriers rather than variations in core competency levels. Teachers of both genders exhibit unique strengths that collectively form vital pillars for rural education's digital

transformation.

In summary, rural teachers in northwestern Guangdong exhibit six core characteristics of digital literacy: First, while the foundational competency framework is initially established, overall proficiency remains relatively low. The tripartite structure of awareness, skills, and responsibility forms the core components, yet these aspects generally demonstrate moderate to low levels, closely correlated with application depth and training support, validating the principle that "depth outweighs breadth." Second, development shows extreme regional disparities, predominantly involving young female teachers with a skill variation coefficient of 0.4, reflecting a fragmented pattern of "minority leadership and majority lag." Third, application behaviors remain superficial, with an average usage frequency of only 1.813, indicating most teachers employ digital technologies exclusively in special contexts rather than integrating them into daily teaching practices. Fourth, digital social responsibility remains weak, showing the highest degree of rightward skew, as most teachers inadequately address cybersecurity concerns and student online behavior guidance. Fifth, professional support systems are lacking, with training participation showing extreme rightward skew—over 90% of teachers have not attended training programs in the past three years—while high perceived barriers create "dual barriers." Sixth, structural gender differences emerge: male teachers demonstrate significantly stronger responsibility awareness, whereas female teachers exhibit heightened perceived barriers but demonstrate "high resilience," with core competencies remaining competitive. This complementary dynamic between genders provides crucial support for educational transformation.

4. Enhancement Pathways

This chapter's enhancement strategy strictly adheres to the progressive logic of "targeted problem-solving, strengthening foundations, deepening applications, value-oriented development, obstacle removal and empowerment, and collaborative synergy." Closely aligned with the six core challenges in digital literacy among rural teachers in northwestern Guangdong, the approach adopts a problem-driven methodology, prioritizes competency development, emphasizes practical application, and ensures ecosystem support. Through systematic implementation and targeted measures, it establishes a comprehensive improvement framework encompassing "foundation consolidation—competency equilibrium—application deepening—value supplementation—barrier elimination—community collaboration," effectively addressing multifaceted challenges in rural teachers' digital literacy development.

4.1 Strengthening Foundations and Enhancing Capabilities: Multidimensional Empowerment for Core Competency Development

The key to enhancing digital literacy among rural teachers lies in awakening their "intrinsic motivation" to facilitate the transformation from "being forced to learn" to "voluntary learning" [7]. Addressing the current situation where core competencies are initially established but generally underdeveloped, with strong correlations to application depth and training support, this study adheres to the competency development principle of "depth over breadth." By integrating digital awareness, technical skills, and social responsibility into routine teaching research, we stimulate teachers' autonomous development through tiered application tasks. The frequency of digital technology usage is incorporated as a core competency indicator, with progressively challenging application tasks designed to promote coordinated development of core competencies and practical application. Simultaneously, we integrate online and offline training resources to establish an integrated "training + application" cultivation model, enabling direct conversion of training outcomes into teaching capabilities and solidifying the foundational basis for core competency development.

4.2 Tiered Cultivation and Targeted Assistance: Bridging the Gap in Group Capacity Differentiation

Beyond the findings of this study, existing academic research also indicates that rural teachers' overall digital literacy levels require improvement, with prevalent core issues including outdated digital awareness concepts, superficial application of digital teaching methods, and insufficient sustainability in digital professional development [8]. To address the highly uneven development patterns where skills exhibit a "minority-led, majority-lagging" gap

structure, a tiered precision cultivation strategy should be implemented to mitigate developmental disparities. Key measures include: selecting digitally proficient leading teachers to form instructional leadership teams for interdisciplinary demonstration teaching; establishing school-based mentorship platforms with core faculty members as key drivers to facilitate rapid skill transfer; designing lightweight, hands-on remedial courses for digitally underprepared teachers focusing on foundational operations and classroom applications; creating dynamic digital literacy growth portfolios to adjust training programs based on competency levels, thereby promoting balanced skill enhancement across teacher tiers and resolving group differentiation challenges.

4.3 Routine-driven Integration of Education into Daily Practice – Promoting Deep Application of Digital Technologies

The essence of digital teaching transformation lies in shifting from "teaching technology" to "technology-assisted instruction," and from "instrumental practice" to "embodied education"[9]. Addressing current challenges such as superficial application behaviors, limited use in special contexts, and low integration into daily teaching practices, this study advocates transitioning digital technologies from "tool demonstrations" to "routine educational integration," achieving deep technological integration rather than superficial application. We establish incentive mechanisms for routine digital teaching adoption, incorporating daily application outcomes into teachers' performance evaluations and excellence criteria to stimulate intrinsic motivation. By analyzing exemplary rural teaching cases, we conduct curriculum research on digital technology integration and "same lesson, different approaches" activities to develop replicable methodologies. Additionally, we optimize lightweight digital teaching tools tailored for rural classrooms and create localized digital resources to reduce implementation barriers, ensuring comprehensive integration of digital technologies throughout the entire teaching process—from lesson preparation and instruction to assignment evaluation.

4.4 Cultivating Spiritual Identity and Shared Education for All – Enhancing Awareness of Digital Social Responsibility

To address the current challenges of weak digital social responsibility awareness and insufficient emphasis on cybersecurity and student online behavior guidance, we aim to strengthen the value dimension of digital literacy while promoting dual improvements in skills and accountability. Cybersecurity protocols, information authentication techniques, and digital ethics will be incorporated into mandatory teacher training modules, with case-based teaching and scenario simulations designed to reinforce educators' sense of responsibility. A "teacher-led + student-participatory" digital responsibility cultivation framework will be established, integrating digital social responsibility education into classroom instruction and campus activities. School-based research initiatives will focus on developing digital responsibility themes, with regular professional development sessions to foster consensus and capabilities in digital education among teachers, ultimately making digital social responsibility an essential competency for educators.

4.5 Resource Allocation and Barrier Removal – Enhancing the Professional Support System

To address the dual challenges of inadequate professional support systems, limited training coverage, and high perceived barriers that create fragmented implementation, we propose establishing a comprehensive, multi-dimensional support framework to overcome developmental constraints. Key measures include: enhancing digital infrastructure investment in rural schools with optimized teaching equipment and network resources to strengthen material foundations; establishing county and school-level technical support teams providing real-time technical consultations and hands-on guidance to resolve implementation obstacles; conducting customized needs assessments to develop tailored solutions for teachers facing equipment shortages, time constraints, or technical challenges; and expanding training resources to every rural school to achieve full coverage, thereby eliminating the "training gap + perception barriers" dilemma. Rural teacher development requires a "localization shift" strategy that leverages regional characteristics and local resources to integrate education into community contexts [10]. This study advocates that digital resource development should avoid replicating urban models while instead adapting to the unique realities of northwestern

Guangdong by creating lightweight digital tools and localized teaching materials tailored for rural settings. This approach ensures organic integration of technological empowerment with cultural heritage preservation, fostering a synergistic "technology-localization-teaching" ecosystem for rural education.

4.6. Gender Complementarity and Synergistic Empowerment: Activating Endogenous Driving Forces for Group Development

The study reveals structural gender disparities: male educators demonstrate stronger accountability awareness, while female teachers exhibit higher perceived resilience and comparable core competencies. Leveraging these group strengths enables synergistic value creation. Male teachers should lead digital social responsibility initiatives by spearheading cybersecurity awareness programs and information ethics education to guide digital responsibility cultivation. Female teachers 'resilience and classroom application expertise should position them as key drivers in integrating digital technologies into daily teaching practices, with focused research on classroom implementation. Establishing gender complementary teaching research mechanisms through cross-gender teams and dual-mentorship systems facilitates experience sharing and skill enhancement among educators. This approach transforms gender differences into collective collaborative advantages, injecting sustainable internal momentum for rural teachers' digital literacy development.

5. Conclusion

This study surveyed 150 rural teachers in northwestern Guangdong Province to assess their current digital literacy status and explore improvement strategies. Results indicate that while the core framework of digital literacy among rural educators in this region has taken initial shape, overall proficiency remains low. Key challenges include uneven development patterns, superficial technology adoption, weak digital social responsibility awareness, lack of professional support systems, and structural gender disparities. Application depth and training support emerged as critical determinants. Based on these findings, the study proposes a progressive enhancement strategy titled "Targeted Problem-Solving and Foundation Strengthening," focusing on six key areas: consolidating core competencies, bridging skill gaps, promoting in-depth application, enhancing responsibility awareness, improving support systems, and fostering collaborative group efforts. These measures provide practical references for improving rural teachers' digital literacy, supporting the digital transformation of rural education and advancing urban-rural educational equity.

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