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Research on the Construction of a Digital Literacy Assessment Model for Higher Vocational College Teachers in the Context of Building a Strong Education System

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Abstract: The pursuit of building a leading education system has imposed new demands on vocational education to cultivate high-caliber technical and skilled professionals; consequently, teachers' digital literacy has become a key determinant of the success or failure of the digital transformation in vocational education. Building upon a clear delineation of the core connotations and extensions of teachers' digital literacy in higher vocational education, this study systematically examines the theoretical underpinnings of the Ministry of Education's Industry Standard for Teachers' Digital Literacy (JY/T 0646-2022), the EU DigCompEdu Framework, the UNESCO Information and Communication Technology Competency Framework (ICT-CFT), and relevant OECD evaluation indicators. Integrating these frameworks with the practical characteristics of "type-specific education" in vocational training, the study proposes a "Three Domains and Nine Dimensions" knowledge and skill model framework for higher vocational teachers' digital literacy-comprising the Knowledge Foundation Domain, Digital Competence Domain, and Digital Identity Domain. Based on this framework, a comprehensive evaluation indicator system is constructed, consisting of 5 primary indicators, 14 secondary indicators, and 36 tertiary observation points. At the mechanism level, the study designs a four-dimensional linkage mechanism encompassing "vocational standards – training – evaluation – incentives," advocating the use of standards as the guiding force, training as the supporting foundation, evaluation as the leverage, and incentives as the driving motivation to establish a dynamic digital literacy development system that adapts to technological evolution, aligns deeply with the distinctive features of vocational education, and effectively stimulates endogenous motivation. An empirical validation was conducted using a sample of 186 full-time teachers from higher vocational institutions; the results demonstrate that the evaluation model exhibits strong reliability, validity, and discriminant power, enabling it to effectively identify structural gaps in teachers' digital literacy, provide a basis for targeted training and personalized professional development, and offer both theoretical and practical insights for the systematic enhancement of teachers' digital literacy within higher vocational institutions in the context of China's efforts to build a leading education system.

Keywords: Building a strong education system; Higher vocational educators; Digital literacy; Assessment model; Four-dimensional linkage mechanism; Educational digital transformation

Received: 02 July 2026

Revised: 25 August 2026

Accepted: 09 September 2026

Published: 15 September 2026



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1. Introduction to the Problem

The new requirements imposed by the Strategy to Build China into a Leading Educational Power on the professional competencies of vocational education teachers

The report to the 20th National Congress of the Communist Party of China explicitly called for "accelerating the building of a strong education system, a strong science and technology sector, and a strong talent pool," placing the development of a strong education system at the forefront of national strategy. The foundational task in building a strong education system lies in strengthening the teaching workforce; however, against the backdrop of the digital wave profoundly reshaping industrial structures and the

education ecosystem, teachers' digital literacy has evolved from a supporting skill into a core competency critical to educational quality. In the Industry Standard on Teachers' Digital Literacy issued by the Ministry of Education in 2022, it is defined as the awareness, capabilities, and responsibility that teachers possess in utilizing digital technologies to acquire, process, use, manage, and evaluate digital information and resources; to identify, analyze, and solve educational and teaching challenges; and to optimize, innovate, and transform educational and teaching practices. This definition affirms, at the national level, the status of digital literacy as a central component of teachers' professional competence.

For higher vocational colleges, this requirement carries particularly urgent practical significance. As the educational sector with the closest ties to the industrial economy, higher vocational education bears the core mission of cultivating technically skilled professionals for advanced manufacturing, modern service industries, and strategic emerging industries. The digital transformation across industries is advancing at an unprecedented pace—new technologies—such as smart manufacturing, the Industrial Internet, digital twins, and artificial intelligence—are being widely integrated into production processes; as a result, the job responsibilities, tools, methodologies, and competency frameworks for frontline technical roles are undergoing a fundamental reshaping. This industrial transformation raises new expectations regarding the qualifications of professionals: higher vocational graduates must not only master traditional operational skills but also possess digital-enabled production collaboration capabilities, data-driven quality awareness, and problem-solving skills leveraging intelligent tools. Ultimately, the upgrading of talent development standards depends on whether educators can lead the way in achieving a leap in their own digital capabilities. If educators themselves lack a deep understanding of digital transformation or the practical skills required to implement it, they will find it difficult to effectively integrate new technologies, processes, and standards into their teaching content, let alone guide students in developing the professional adaptability needed in the digital age during practical training sessions.

The Current State of Digital Literacy among Higher Vocational Education Teachers and the Challenges in Its Assessment: In reality, there exists a significant gap between the overall level of digital literacy among vocational college teachers and the requirements for building a strong education system. Numerous survey studies indicate that vocational college teachers still face structural shortcomings in terms of their operational proficiency with digital tools and their depth of integration of digital teaching methods. A prominent contradiction lies in the fact that while the use of digital technologies in teachers' daily lives is highly prevalent, this "consumptive digital literacy" has not naturally evolved into "educative digital literacy." The proportion of teachers who actively integrate digital technologies into their instructional design, employ virtual simulation tools during practical training sessions, or utilize learning analytics technologies in the assessment process remains relatively low. Scholars such as Wang Youmei have characterized this phenomenon as a disconnect between the instrumental mastery of digital literacy and its transformative application in education.

The causes of this disconnect are multifaceted, but one underlying factor lies in the absence or misalignment of an effective evaluation system. Currently, vocational colleges face three prominent issues in their approaches to assessing teachers' digital literacy: First, the evaluation criteria are overly generalized, frequently drawing upon the same indicators used to assess university teachers' information technology-based teaching capabilities, yet failing to adequately address the distinctive characteristics of vocational education; Second, the evaluation process is superficial, focusing primarily on whether technology is "used" rather than whether it "effectively facilitates skill acquisition and the development of digital literacy"; Third, there is a weak linkage mechanism between evaluation outcomes and teacher professional development—evaluations are disconnected from training and incentive mechanisms, making it difficult to establish a closed-loop system where "evaluation drives improvement." As Yang Zhenzhen has pointed out, current research lacks a comprehensive digital literacy assessment model tailored

specifically to the unique characteristics of vocational college teachers; most existing assessments represent merely a simple adaptation of the digital literacy assessment framework designed for general education teachers, failing to fully capture the unique role expectations placed on vocational college teachers as "digital craftsmanship" cultivators.

2. Current State of Related Research

2.1. The Evolution of the Digital Literacy Concept and the Academic Context of Teachers' Digital Literacy

The concept of digital literacy has evolved from mere technical operational skills to a comprehensive set of competencies. The Israeli scholar Yoram Eshet-Alkalai was the first to systematically propose a framework for digital literacy, comprising five dimensions: visual literacy, reproduction literacy, branching literacy, information literacy, and social-emotional literacy. A key contribution of this framework lies in breaking away from the narrow perception that "digital literacy = computer skills," by incorporating cognitive abilities, critical thinking, and social-emotional dimensions into the broader scope of digital literacy.

In the field of teacher professional development, research on digital literacy has evolved through three distinct phases. The first phase (2000–2010) centered on the concept of "Information Technology Application Competence," focusing on whether teachers could operate basic software and hardware tools, with the evaluation primarily assessing the proficiency of these operational skills. The second phase (2010–2020) shifted its focus to "the integration of technology and teaching," as exemplified by the TPACK (Technology–Pedagogy–Content Knowledge) framework, which emphasized the interdisciplinary integration of technological knowledge, pedagogical knowledge, and subject matter knowledge; accordingly, the evaluation of digital literacy moved from assessing whether teachers "could use the technology" to evaluating whether they "used it effectively." The third phase (2020–present) marks the emergence of the "Comprehensive Literacy in the Era of Digital Transformation" stage. Against the backdrop of the deep integration of emerging technologies-such as generative artificial intelligence, big data, and virtual simulation-the concept of teacher digital literacy has been further expanded to encompass new dimensions-including digital ethics, digital identity, and human-machine collaboration; thus, the core of evaluation has shifted from "technology integration capability" to "digital competence."

2.2. Comparative Analysis of Major International Digital Literacy Frameworks for Teachers

2.2.1. EU DigCompEdu Framework

The "EU Digital Literacy Framework for Educators" (DigCompEdu), published in 2017 by the Joint Research Centre of the European Commission, is one of the most comprehensive international frameworks for teachers' digital literacy. This framework encompasses six key competency domains: Professional Engagement, Digital Resources, Teaching and Learning, Assessment, Empowering Learners, and Facilitating Learners' Digital Competence. The distinctive features of DigCompEdu are as follows: First, it expands the teacher's role from that of a "technology user" to that of a "digital educator" and a "competency facilitator," emphasizing that teachers should not only possess digital literacy themselves but also be capable of fostering the digital literacy of their students-particularly future technical and skilled professionals in the context of vocational education; Second, it employs a six-stage development model (Novice – Explorer – Integrator – Expert – Leader – Pioneer), providing a tiered reference framework for assessment and development; Third, the framework is highly flexible and adaptable, allowing it to be tailored to different types and levels of education based on specific contextual requirements.

2.2.2. Unesco Ict-cft Framework

The UNESCO-published *Teacher Information and Communication Technology Competency Framework* (ICT-CFT) focuses on the competency structure that enables teachers to leverage ICTs in supporting the achievement of educational objectives; it encompasses six competency domains: understanding ICTs in educational policy; curriculum and assessment; teaching methodology; application of digital skills; organization and management; and professional development for teachers. For higher vocational education, the ICT-CFT's policy-related perspective offers important insights: the definition of digital literacy among higher vocational educators must be closely aligned with the talent development goals of vocational education and the policy direction of industry–education integration.

2.2.3. OECD Digital Literacy Related Assessment Indicators

The OECD's contributions to digital literacy assessment are primarily reflected in two areas: first, it has incorporated dimensions for measuring digital literacy and digital skills into large-scale international assessments such as PISA, thereby providing cross-national comparative data to understand the level of digital literacy among students within educational systems; second, in its research on Technology and Vocational Education and Training (TVET) as well as the digital transformation of higher education, the OECD has highlighted the need to monitor and assess digital competence; notably, the OECD places particular emphasis on the "problem-solving ability in real-world contexts" as an assessment orientation in its approach to digital literacy evaluation, advocating the use of task-based performance-based assessment (rather than traditional paper-and-pencil tests) to measure learners' digital literacy.

Comparison and implications of the three frameworks: The EU's DigCompEdu provides the most comprehensive dimensional framework and phased model; UNESCO ICT-CFT offers a policy-relevant and goal-oriented analytical perspective; while the OECD contributes a methodological approach centered on performance-based assessment in real-world contexts. However, all three frameworks are designed for "educators in the general sense" and do not fully address the distinctive characteristics of vocational education—such as the digital skills requirements for "dual-qualified" teachers, the need for virtual simulation capabilities in practical training, or the digital collaboration literacy required in school-enterprise partnerships. This represents the theoretical space within which this study should be localized and adapted to the specific realities of higher vocational education in China.

2.3. An Overview of the Current State of Research on Digital Literacy among Domestic Higher Vocational Education Teachers

1. Research on standards based on national standards. The release of the Ministry of Education's 2022 Industry Standard on "Teacher Digital Literacy" provides an authoritative foundation for related research. This standard establishes a literacy framework comprising five primary dimensions (Digital Awareness, Digital Technology Knowledge and Skills, Digital Application, Digital Social Responsibility, and Professional Development), 13 secondary dimensions, and 33 tertiary dimensions. Several scholars have built upon this framework to provide specific interpretations tailored to the characteristics of higher vocational education. Fu Congrong et al. argue that the core essence of digital literacy among higher vocational educators lies in their ability to utilize digital technologies to acquire and process information, innovate teaching activities, solve instructional challenges, as well as their corresponding sense of responsibility and digital mindset.

2. A self-developed framework grounded in academic logic. Scholars such as Wang Youmei have proposed a "Four-Dimensional Logical Framework" for the digital literacy of vocational college teachers, which encompasses: Digital Survival Literacy (the fundamental instrumental knowledge and skills required to adapt to digital environments); Digital Thinking Literacy (the ability to critically select and deeply analyze digital information); Digital Application Literacy (the ability to use technology to solve practical educational and teaching problems); and Digital Coexistence Literacy (the ability

to coexist with digital technologies and foster a culture of a digital teaching community). The contribution of this framework lies in revealing, from an epistemological perspective, the hierarchical progression of digital literacy-ranging from "whether one can survive in a digital environment" to "whether one can coexist with digital technologies." However, this framework is predominantly theoretical in nature, and its operationalization indicators require further refinement.

3. The "Three-Dimensional Model" tailored to the characteristics of higher vocational education. The three-dimensional digital literacy model for higher vocational educators proposed by Yang Zhenzhen has garnered considerable attention in recent years. This model categorizes higher vocational educators' digital literacy into three major dimensions-knowledge foundation, digital competence, and digital identity-and breaks them down into 13 secondary dimensions: the knowledge foundation encompasses digital knowledge, digital innovation, digital office work, and digital security; digital competence includes digital collaboration skills, digital teaching capabilities, digital research capabilities, and digital practical skills; and digital identity focuses on the identity and role construction of higher vocational educators as "digital artisans, technical artisans, skill-based artisans, and wisdom-based artisans." The core insight of this model lies in the introduction of the "digital identity" dimension-this dimension transcends the traditional "knowledge-skill" binary framework by incorporating educators' professional identity, value orientations, and developmental aspirations into the composition of digital literacy. This approach is inherently consistent with the emphasis on endogenous driving forces in the development of a leading education nation.

3. Construction Pathways and Methods for a Digital Literacy Assessment Model for Higher Vocational College Teachers in the Context of Building a Strong Education System

3.1. The Logical Framework for Constructing Theoretical Models and the "Three Domains, Nine Dimensions" Framework

3.1.1. Conceptual Definition: An Ontological Interpretation of Digital Literacy among Higher Vocational Education Teachers

The digital literacy of vocational college teachers refers to their ability, within the dual context of digital industrial transformation and the digital transformation of education, to critically develop and utilize various digital tools and resources to enhance the quality of cultivating technical and skilled talent, and to creatively apply digital technologies to address educational and instructional challenges; through this process, they demonstrate a comprehensive competency encompassing digital knowledge, digital skills, and digital identity as an integrated triad. Firstly, the objective of vocational college teachers' digital literacy is to improve the quality of cultivating technical and skilled talent, rather than general educational quality; this implies that the criteria for evaluating their digital literacy should ultimately be based on the industrial relevance of the talent they cultivate. Secondly, the core competency of vocational college teachers' digital literacy lies in "critical development and creative application" -emphasizing active construction rather than passive use-meaning they are capable of developing, adapting, and creating digital resources and tools in accordance with the demands of the vocational education context. Thirdly, the structural characteristic of vocational college teachers' digital literacy is the integration of "knowledge-competence-identity"; among these, the "identity" dimension underscores the emphasis on teachers' role identification and value awareness as "digital craftsmanship nurturers."

3.1.2. Model Development: From the "Five-Dimensional Standard Framework" to the "Three-Domain, Nine-Dimensional Theoretical Model"

In terms of model development methodology, this study employs a three-step integration strategy comprising "standard kernel + vocational education extension + mechanism-based relationship."

The first step involves using national standards as the core framework. The five primary dimensions of the Ministry of Education's Industry Standard for Teachers' Digital Literacy-Digital Awareness, Digital Technology Knowledge and Skills, Digital Application, Digital Social Responsibility, and Professional Development-serve as authoritative guidelines within China's educational administrative context and constitute the "legitimacy core" for any localized model. This standard has undergone a rigorous development process and encompasses 13 secondary dimensions and 33 tertiary dimensions, demonstrating strong systematicity and comprehensiveness.

Step 2: Extend the scope based on the typological characteristics of vocational education. The typological features of higher vocational education necessitate an expansion of the standard core across three dimensions: First, the vocational dimension of knowledge and skills-building upon general digital knowledge by incorporating mastery of industry-specific digital technology knowledge; Second, the application-oriented practical training approach-integrating the "digital practical training" scenario, which is unique to higher vocational education, into the "Design-Implementation-Evaluation" chain of general digital teaching, with a focus on teachers' ability to deliver practical instruction using technologies such as virtual simulation, digital twins, and remote collaboration; Third, the industry-education collaboration dimension within the context of responsibility and development-expanding the scope of digital social responsibility from ethical and safety considerations within the classroom to privacy protection in school-enterprise data sharing and the new professional ethics requirements arising from industrial digitalization; and Fourth, professional development should reflect the continuous updating of "dual-qualified" teachers' digital literacy in alignment with the iterative evolution of industrial technologies.

Step 3: Analysis of Mechanistic Relationships. Drawing upon the empowerment logic of the EU's DigCompEdu initiative – "Enhancing Student Competencies through Teacher Competence Development" – the goal-oriented linkage logic of UNESCO's ICT-CFT framework (Policy-Curriculum-Teaching-Assessment) – and the spiral promotion relationship depicted in Yang Zhenzhen's Three-Dimensional Model (Knowledge Base → Competency Enhancement → Identity Formation), this study develops a "Three Domains, Nine Dimensions" theoretical model for the digital literacy of vocational college teachers:

The Knowledge Domain (Knowing) comprises three dimensions: Digital Knowledge, Digital Innovation Knowledge, and Digital Security Knowledge.

The Digital Competence Domain (Doing) comprises four dimensions: Digital Teaching Competence, Digital Practice Competence, Digital Collaboration Competence, and Digital Research and Reflective Competence.

The Digital Identity Domain (Being) comprises two dimensions: Digital Craftsman Identity and Digital Development Awareness.

The logical mechanism of this model lies in the following: the knowledge foundation domain serves as the cognitive prerequisite for enhancing the digital capability domain; the growth of the digital capability domain strengthens the identity recognition within the digital identity domain through practical outcomes; and the strength of this identity recognition, in turn, regulates the level of investment in knowledge acquisition – together these three elements form a virtuous cycle of "cognition-behavior-meaning."

3.2. Construction of the Assessment Indicator System

3.2.1. Final Structure of the Evaluation Indicator System

Following the aforementioned procedure, a digital literacy assessment indicator system for higher vocational college teachers was ultimately developed, comprising 5 primary indicators, 14 secondary indicators, and 36 tertiary observation points. It should be noted that the establishment of the primary indicators adheres to the logic of the "Three Domains" model; meanwhile, the "Digital Awareness" concept from the national standard has been retained as an independent primary indicator (by placing it separately within the "Digital Identity Domain" to highlight the leading role of awareness in the

development of digital literacy), and indicator content tailored to the characteristics of higher vocational education has been incorporated. The correspondence between the primary indicators and the "Three Domains" is shown in table 1:

Table 1. Digital Literacy Assessment Indicator System and Domain Correspondence for Higher Vocational College Teachers.

Primary Indicator	Domain	Secondary Indicator
A. Digital Awareness	Digital Identity Domain	A1 Digital Transformation Awareness; A2 Digital Vocational Education Awareness; A3 Digital Learning Intention;
B. Digital Technology Knowledge and Skills	Knowledge Foundation Domain	B1 General Digital Technology Knowledge; B2 industry digital technology knowledge; B3 Digital Security and Ethics Knowledge
C. Digital Teaching Applications	Digital Competence Domain	C1 Digital Teaching Design; C2 digital resource development; C3 Digital Classroom Teaching; C4 Digital Practical Training;
D. Digital Collaboration and Scientific Research	Digital Competence Domain	D1 Digital Teaching and Research Collaboration; D2 Digital School-Enterprise Collaboration; D3: Data-Driven Reflection and Research
E. Digital Social Responsibility and Professional Development	Digital Identity Domain	E1: Digital Ethics and Privacy Protection; E2 – Ensuring Educational Equity; E3 Digital Professional Development Plan E4 Digital Lifelong Learning Practice

3.2.2. Determination of Indicator Weights

The Analytic Hierarchy Process (AHP) was employed to determine the weights of indicators at each level. Members of the aforementioned expert panel were invited to conduct pairwise comparison judgments on the indicators, thereby constructing a judgment matrix. After passing the consistency test ($CR < 0.1$), the geometric mean method was used to aggregate the experts' opinions and derive the weights of the indicators at each level. The weights of the primary indicators are as follows: Digital Awareness (0.15), Digital Technology Knowledge and Skills (0.22), Digital Teaching Applications (0.30), Digital Collaboration and Research (0.13), and Digital Social Responsibility and Professional Development (0.20). The highest weight is assigned to Digital Teaching Applications, reflecting the "application-oriented" practical approach of higher vocational education; the weight for Digital Technology Knowledge and Skills is the next highest, highlighting the emphasis on equipping vocational education teachers with "industry-specific digital technology expertise."

3.3. Design of the "Four-Dimensional Linkage Mechanism": The Operational Environment for the Assessment Model

The value of assessment models lies not merely in "measuring" but, more importantly, in "promoting." Within the context of building a strong education system, assessment should be integrated into a comprehensive teacher development ecosystem, serving as an engine that drives continuous improvement. This study has designed a four-dimensional interconnected mechanism encompassing "Professional Standards – Training – Assessment – Incentives":

3.3.1. Professional Standards Dimension: Benchmark for Assessment

Professional standards serve as the foundation for the four-dimensional framework, providing legal legitimacy and a basis for assessment. Building upon the national "General Standard for Teachers' Digital Literacy," higher vocational institutions should develop school-specific, discipline-based digital literacy standards tailored to their unique

disciplinary cluster characteristics. These standards include: First, a "3+X" standard architecture – where "3" represents the foundational digital literacy, digital teaching literacy, and digital development literacy shared by all higher vocational educators; and "X" refers to specialized digital literacy modules designed according to the industrial digitalization characteristics of different major disciplinary fields.

3.3.2. Training Dimension: Support Channel for Assessment

The diagnostic outcomes from assessments can only fulfill the function of "using assessment to drive improvement" when they are translated into targeted training initiatives. Key considerations in designing the training framework include: a tiered, categorized modular training system – whereby teachers' digital literacy gaps are classified into categories such as "awareness gap," "knowledge gap," "application gap," or "collaboration gap" based on assessment results, and tailored training plans are then provided; a blended learning approach – combining online self-directed learning with offline workshops, supported by AI-powered teaching assistants to offer real-time, personalized guidance; and industry-education integrated practical training – collaborating with enterprises to organize immersive workplace placements for teachers, enabling them to enhance their industry-specific digital literacy within authentic corporate digital environments.

3.3.3. Evaluation Dimension: Assessment Implementation Mechanism

The design of the evaluation dimensions adheres to the principle of "multiple stakeholders, multidimensional data, and dynamic tracking." "Multiple stakeholders" refers to establishing a comprehensive evaluation mechanism that integrates teacher self-evaluation, peer review, student assessment, enterprise evaluation, and expert assessment—particularly by incorporating enterprise stakeholders to anchor the "Industry Digital Technology Adaptability" dimension, which is a distinctive feature of higher vocational education; "Multidimensional data" entails combining online teaching platform behavioral data (e.g., volume of digital resource uploads, frequency of blended learning implementation, usage logs of virtual simulation tools) with offline evaluation data (e.g., classroom observation scores, instructional design reviews) to achieve the integration of formative and summative assessment; "Dynamic tracking" involves leveraging big data technologies to construct a "digital literacy profile" for teachers, enabling continuous monitoring of their professional competency development rather than conducting a one-time final assessment.

3.3.4. Incentive Dimension: The Driving Force Behind Assessment

The core of the incentive framework lies in firmly linking assessment outcomes to teachers' professional development interests, while ensuring the diversity and positive nature of the incentive mechanisms. Specific measures include: incorporating digital literacy assessment results into reference indicators for professional title evaluation and appointment, job performance appraisal, and recognition programs; establishing special honors such as the "Digital Teaching Model Teacher" award and the "Digital Resource Development Award"; granting teachers who demonstrate outstanding performance in digital teaching innovation priority in applying for teaching reform projects and providing them with academic resource support; and creating a platform to showcase teachers' digital literacy through digital teaching competitions and achievement displays, thereby fostering positive social recognition. It is important to emphasize that the ultimate goal of these incentives is not to impose external pressure, but rather to stimulate teachers' intrinsic motivation to enhance their digital literacy through a chain of "visible outcomes – recognized honors – development opportunities."

4. Practical Validation of the Model

4.1. Verification Design

To validate the effectiveness of the assessment model, this study conducted an empirical validation at a higher vocational college (a participant in the national "Double High Plan" initiative).

Sample selection: A total of 186 full-time faculty members from five secondary colleges at the institution were selected as participants in the assessment. **Assessment tool:** The "Higher Vocational Education Faculty Digital Literacy Assessment Scale" was developed based on the indicator system; it comprises 36 assessment items and employs a five-point Likert scale (1 = completely does not conform, 5 = completely conforms). Additionally, the "Digital Teaching Behavior Data Collection Protocol" was designed to extract faculty members' digital teaching behavior data from the backend of the university's teaching platform-covering the digital teaching behavior data during the semester preceding the assessment (including online teaching duration, number of digital resources uploaded, frequency of use of virtual simulation tools, number of times participating in online teaching and research activities, etc.)-which served as the criterion data for the self-assessment scale.

Implementation of Multi-dimensional Assessment: In line with the design for multiple stakeholders outlined in the assessment model, the following assessments were conducted: teacher self-evaluation (100% coverage), peer evaluation (mutual evaluation conducted by groups within each teaching and research office), student evaluation (each teacher randomly selected 20 students to evaluate their digital teaching experience), and teaching administrator evaluation (performed by the Associate Dean of Teaching and the Head of each teaching and research office at the secondary college level). The comprehensive score was calculated by weighting these four assessment components as follows: teacher self-evaluation (20%), peer evaluation (30%), student evaluation (25%), and administrator evaluation (25%).

4.2. Validity and Reliability Testing

Reliability analysis: The Cronbach's α coefficient was used to assess the internal consistency of the scale. The overall scale's α coefficient was 0.932, indicating high internal consistency reliability. A retest was conducted among 45 teachers after an interval of six weeks; the retest reliability (Pearson correlation coefficient) was 0.867 ($P < 0.01$), demonstrating good cross-temporal stability of the scale.

Structural validity analysis: Confirmatory factor analysis (CFA) was employed to test the structural validity of the assessment model. The model fit indices were as follows: $\chi^2/df = 2.84$ (< 3), RMSEA = 0.062 (< 0.08), CFI = 0.913 (> 0.90), TLI = 0.901 (> 0.90), and SRMR = 0.058 (< 0.08). All fit indices fell within acceptable ranges, supporting the five-dimensional assessment structure corresponding to the "Three Domains, Nine Dimensions" theoretical model. The standardized factor loadings for each observed indicator ranged between 0.58 and 0.84, all of which were statistically significant ($P < 0.001$), indicating that the observed indicators are highly representative of their respective dimensions.

4.3. Assessment Results Analysis

Overall level: The mean digital literacy score for the 186 teachers was 3.42 (on a 5-point scale), placing them overall at the "moderate" level (3.0–3.99). The scores across the primary dimensions varied: Digital awareness scored the highest at 3.78; Digital teaching application scored moderately at 3.45; Digital technology knowledge and skills scored relatively low at 3.21; and Digital collaboration and research scored the lowest at 3.02 – the latter representing the weakest component. This finding aligns with the earlier research observation that "awareness precedes behavior": while vocational college teachers generally recognize the importance of digital transformation at the cognitive level, there remains a significant gap between this awareness and the actual implementation of deep teaching practices and collaborative initiatives.

Group differences: Across the broad disciplinary categories, faculty members from the School of Information Technology generally scored higher than those from other schools (overall score: 3.87); the School of Intelligent Manufacturing followed (3.52); the

School of Finance and Business (3.31) and the School of Health and Nursing (3.18) scored in the middle range; while the School of Architecture and Art (3.06) had the lowest score. This disparity reflects, in part, the "digital density" inherent in each discipline; however, the variation among the schools was greater in the "Digital Practical Training Teaching" dimension—a characteristic feature of higher vocational education—than in the "Digital Classroom Teaching" dimension (standard deviations: 0.83 and 0.61, respectively). This indicates an extremely uneven distribution of the application of practical digital technologies, such as virtual simulation, across higher vocational institutions, revealing a clear divergence between "high-performing faculty members" and "underperforming faculty members."

In terms of professional title distribution, a "U-shaped" pattern emerges: the teaching assistant/lecturer group scores relatively high at 3.51, the associate professor group scores the lowest at 3.22, while the professor group's score has risen to 3.55. However, faced with the dual pressures of research obligations and administrative duties, professors tend to devote relatively less effort to digital teaching; moreover, their existing teaching practices are characterized by strong "path dependency," which may result in insufficient motivation to change or inadequate external support. The rise in the professor group's score can be partly attributed to their advantages in digital research and digital collaboration, as well as their greater opportunities to participate as "lead figures" in digital teaching reform initiatives.

5. Research Findings

5.1. Theoretical Contribution of the Model

The "Three Domains and Nine Dimensions" model (Knowledge Foundation – Digital Competence – Digital Identity), developed through this research, achieves triple integration: it integrates the authoritative framework of national standards with the typological characteristics of higher vocational education; it combines international theoretical resources—such as the EU's DigCompEdu, UNESCO's ICT-CFT, and OECD evaluation indicators—with China's localized practical needs; and it encompasses the cognitive dimension (knowledge), behavioral dimension (competence), and meaning dimension (identity) of digital literacy. In particular, the introduction of the "Digital Identity" dimension elevates teachers' digital literacy from a "trainable set of skills" to a "constructive professional identity," providing a new theoretical perspective for understanding the endogenous driving mechanisms behind the development of teachers' digital literacy.

(2) At the mechanism design level, the "Four-Dimensional Linkage Mechanism" (Vocational Standards – Training – Assessment – Incentives) provides a comprehensive institutional framework for translating assessment outcomes into developmental actions, addressing the need for a closed-loop approach encompassing "what to assess – how to train – how to evaluate – and how to motivate." The core design philosophy of this mechanism is "using assessment as a lever to drive development," rather than "using assessment as a yardstick to distinguish excellence from inferiority"; this aligns with the teacher development philosophy advocated by the initiative to build a strong education system – namely, "that every individual can achieve success and fully realize their potential."

5.2. Practical Value of the Research

At the school governance level: Higher vocational institutions can directly adopt or adapt the assessment indicator system developed in this study to establish a regularized monitoring mechanism for teachers' digital literacy. At the teacher development level: The assessment model provides teachers with a reference framework for self-diagnosis and professional development. Through the assessment results, teachers can identify their "digital literacy profile," recognize their strengths and areas for improvement, and subsequently develop personalized development plans. At the policy design level: The "3+X" standard framework and the tiered achievement-based design proposed in this

study serve as a reference template for educational administrative authorities when developing classification standards and implementation guidelines for the digital literacy of higher vocational educators.

Funding: This work was supported by the 2025 Key Project for Chongqing Vocational Education Teaching Reform (Grant Number: Z2252042).

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