Theoretical Framework and Logical Rationale for Enhancing New Farmers' Digital Literacy through the "Rural-School Collaboration" Model under the Digital Rural Strategye

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Abstract: The implementation of the Digital Rural Strategy has created an urgent demand for digital literacy among new farmers. However, the existing education and training system is plagued by challenges such as fragmented resources, a mismatch between supply and demand, and a disconnect between instructional content and practical application. The Rural-School Collaboration model, which integrates the practical contexts of rural areas with the professional resources of educational institutions, offers a viable pathway to address these bottlenecks. Drawing upon theories of collaborative governance, lifelong education, and the digital divide, this study constructs a theoretical framework and delineates the logical rationale for this empowerment model. The framework comprises four core elements: enabling agents, content systems, delivery mechanisms, and support systems. It follows a value chain logic of driving force-knowledge transformation-capability transfer-supportive guarantee. The content system is structured as a three-tiered progressive framework consisting of foundational, specialized, and distinctive components. Regarding its operational logic, the model adheres to a four-part sequential process: needs identification and resource matching, collaborative teaching and practice integration, feedback optimization and capacityupgrading, and value transformation and radiation-driven promotion. These four stages are interconnected and cyclical, forming a complete dynamic empowerment loop. This study elucidates the operational mechanisms of the Rural-School Collaboration model, thereby providing theoretical support and practical guidance for optimizing the cultivation pathways for new farmers and advancing the development of digital villages.

Keywords: Digital Rural Areas; Rural-School Collaboration; New Farmers; Digital Literacy; Empowerment Mechanism; Theoretical Framework

1. Introduction

1.1 Problem Statement

Digital villages represent the deep integration of agricultural and rural modernization with digital transformation, serving as a pivotal lever for the national rural revitalization strategy. Since the Digital Rural Areas Strategy was first proposed, a series of policy documents-including the Development Plan for Digital Agriculture and Rural Areas and the Action Plan for Enhancing the Digital Literacy and Skills of the Entire Population-have consistently identified the enhancement of farmers' digital technology application capabilities and the expansion of the rural professional talent pool as core priorities. These policies underscore the strategic centrality of new farmers' digital literacy in the construction of digital rural areas.

Nonetheless, as direct participants in digital village construction and potential beneficiaries of the digital dividend, the new generation of farmers generally exhibits deficiencies in digital literacy, such as inadequate skills in applying digital technologies and weak information discernment capabilities. These shortcomings severely constrain the in-depth integration of digital technologies into agricultural production and rural governance. Currently, digital literacy education for this demographic faces prominent challenges, including the uneven distribution of educational and training resources and a disconnect between curriculum content and actual production practices. The Rural-School Collaboration model, which leverages the complementary resources of rural communities and educational institutions, presents new opportunities to overcome these systemic bottlenecks.

This study addresses the following core research questions: How can the Rural-School Collaboration

model theoretically construct a mechanism to empower new farmers' digital literacy? What are its essential components and intrinsic operational logic? Through a systematic analysis of these questions, this study aims to provide both theoretical support and practical guidance for the development of digital rural communities and the cultivation of new farmers.

1.2 Current State and Review of Domestic and International Research

The deepening advancement of the Digital Rural Strategy has positioned new farmers as the core driving force behind rural revitalization and the digital transformation of agriculture; their digital literacy directly determines the effectiveness of digital technology implementation and the quality of rural digital economic development. Scholars both domestically and internationally have conducted systematic research on the conceptual framework, empowerment value, constraining factors, and cultivation pathways pertaining to new farmers' digital literacy. This has resulted in a robust research system that balances theoretical inquiry with empirical evidence. While the findings are abundant, there remains room for further optimization, providing a solid foundation for subsequent investigations.

1.2.1 Conceptual definitions and framework construction

A consensus has largely been reached within the academic community regarding systematic framework development. Building upon the UNESCO Global Digital Literacy Framework and integrating farmers' specific digital needs, Li et al. constructed a framework for farmers' digital literacy comprising five dimensions: digital proficiency, security and ethics, communication, creation, and problem-solving [1]. Wei and Ma further refined the focus to the new farmer demographic, delineating their digital literacy into five modules: digital awareness, learning ability, operational skills, problem-solving capacity, and digital ethics, with an emphasis on adaptability to agricultural contexts [2]. Su and Peng proposed a four-dimensional evaluation system-General, Social, Creative, and Security-from a daily practice perspective, addressing the practical limitations of earlier framework studies [3]. Early foundational theories of digital literacy from abroad (Eshet-Alkalai; Gilster) provided the theoretical underpinnings for domestic research, which subsequently evolved beyond a narrow focus on individual technical skills toward a composite literacy system tailored to the specificities of agricultural digitization [4,5].

1.2.2 Empowerment value and mechanisms of action

Empirical studies have extensively validated the core driving role of digital literacy. Based on data from the primary apple-producing regions of Shaanxi Province, Mao et al. confirmed that digital literacy can promote fertilizer reduction and enhance green production efficiency, thereby achieving both ecological and economic benefits [6]. Qiu et al. found that digital literacy significantly facilitates farmers' entrepreneurial decision-making by augmenting human, social, and psychological capital, encompassing the entire process from opportunity identification to resource integration and risk management [7]. Wen et al. and Wang et al. further substantiated that digital literacy increases farmers' participation in digital finance and improves the operational performance of family farms, thereby broadening income-generating channels [8,9]. Ma and Xue introduced the theory of gradient embedding, positing that the digital literacy of new-generation farmers facilitates embedding across four layers-market, culture, community, and public welfare-thereby generating a digital feedback effect [10]. Wang and Mei argue that digital literacy is central to farmers' digital transformation, capable of bridging the digital divide, driving governance reform, and supporting modernization [11]. International research (e.g., Arouna et al.) similarly corroborates the positive impact of digital technology and literacy on agricultural productivity, with domestic and international findings providing complementary insights [12].

1.2.3 Practical challenges and influencing factors

Research has converged on two core issues: the digital divide and bottlenecks in capacity building. Fu and Tang highlight that rural areas confront a dual digital divide encompassing both access and usage, with pronounced group disparities stemming from age, educational attainment, and gender, often leaving middle-aged, elderly, and female populations at a disadvantage [13]. Yao points out that capacity-building initiatives are frequently hindered by insufficient publicity, disjointed content, and outdated facilities, which impede farmers' digital application and income-generating potential [14]. Through empirical research, Song et al. identified an imperfect training system, weak teaching resources, and insufficient industry-academia-research collaboration as key constraints on digital literacy improvement [15]. Sun et al. employing grounded theory, proposed that family support, risk attitudes, and entrepreneurial cognition

significantly influence the digital learning intentions of new farmers [16]. Shi and Hu further contend that uneven rural digital infrastructure, inadequate product supply, and a lack of targeted training exacerbate these challenges, resulting in an overall situation characterized by weak foundations, supply-demand mismatches, and insufficient motivation [17].

1.2.4 Development pathways and practical models

Solutions involving multi-stakeholder collaboration have increasingly come to the fore. Vocational education and open universities have emerged as core platforms for addressing these issues. Liu and Wei propose that vocational education should optimize its curriculum, strengthen its dual-qualified faculty, and establish robust cross-sectoral collaboration mechanisms [18,2]. Drawing on workplace learning theory, Cui et al. developed a context-participation-transformation practical pathway designed to foster the integration of learning and application [19]. The empowerment potential of digital technology has become a key direction for innovation; Shi and Liu advocate for leveraging live streaming and virtual reality (VR) to create immersive learning experiences and for implementing micro-credentialing systems to enhance learner motivation [17,20]. International experiences offer valuable comparative insights; Zou and Jin summarize South Korea's Bongnongwon OMO blended education and O2O2O marketing models, providing references for localized implementation [21]. Ma and Yong advocate for the establishment of collaborative platforms among government entities, schools, enterprises, and villages to integrate resources and cultivate synergistic talent development [22,23].

While the existing literature provides valuable insights, further investigation is warranted in the following areas. First, although international studies offer useful frameworks for school-community collaboration, their direct applicability to China's specific agricultural and rural realities is limited, necessitating the development of localized theories tailored to the national context. Second, while domestic research has thoroughly analyzed the connotations and current status of new farmers' digital literacy, there is a relative paucity of research focused on the specific educational models designed to cultivate these competencies. Third, existing studies have not sufficiently addressed the need to refine and enhance current education and training models from a multi-dimensional perspective that includes new farming households, educational institutions, new types of agricultural business entities, and local governments.

In light of this, the present study aims to systematically examine the key factors and implementation strategies inherent in the Rural-School Collaboration model for digital literacy education among new farmers. This examination is grounded in an analysis of the current status, challenges, and needs within the context of digital rural development. The study ultimately seeks to provide targeted strategies and guidance to support digital transformation and rural revitalization.

2. Definition of Core Concepts and Theoretical Foundation

2.1 Definition of Core Concepts

2.1.1 Digital village strategy

This paper posits that the Digital Rural Strategy is a systematic initiative whose core objectives are to drive the modernization of agriculture and rural areas through digital technology and to narrow the urban-rural digital divide. The strategy encompasses not only the development of rural digital infrastructure and the digital transformation of the agricultural industry but also clearly identifies an urgent need for new farmers to possess digital literacy in areas such as agricultural digital operations, rural e-commerce management, and agricultural data management and application. From the perspective of policy evolution, the Digital Village Strategy has progressively deepened from top-level design to specific implementation pathways and has become a key driver of the broader Rural Revitalization Strategy.

2.1.2 New farmers

This paper defines new farmers as a distinct category of agricultural operators who differ fundamentally from traditional farmers. Leveraging the Internet Plus New Media paradigm and adhering to a modern agricultural mindset characterized by innovation, sustainability, and market orientation, they engage in agricultural production, management, or service activities. The new farmers demographic primarily includes young returning entrepreneurs, veterans, rural e-commerce practitioners, and leaders of agricultural cooperatives. Within the context of digital village construction, they serve not only as recipients of empowerment but also as core participants and direct beneficiaries who actively drive the digital transformation of agriculture and rural areas.

2.1.3 Digital literacy of new farmers

This paper argues that the digital literacy of new farmers is not a singular technical skill but rather an

organic synthesis of various capabilities required in their agricultural production and daily lives. Specifically, it comprises four core dimensions: general digital literacy, social literacy, creative literacy, and security literacy. General digital literacy encompasses the operation of smart devices and basic software applications; social literacy manifests as information exchange and collaboration via digital platforms; creative literacy involves the use of digital tools for content creation and marketing innovation; and security literacy pertains to data protection and cybersecurity awareness. These four dimensions are mutually reinforcing and collectively constitute the foundational competencies required for new farmers to adapt to the evolving landscape of digital rural communities.

2.1.4 The rural-school collaboration model

This paper defines the Rural-School Collaboration model as an institutional framework established under the aegis of the Digital Rural Strategy, with the shared objective of enhancing new farmers' digital literacy. Within this framework, rural entities (including village committees, cooperatives, agricultural enterprises, and family farms) and educational institutions (including vocational schools, universities, and open universities) engage in collaborative partnerships based on resource complementarity. Through formalized cooperation mechanisms and shared platforms, they integrate rural practical scenarios and production needs with the schools' curriculum systems, faculty expertise, and instructional facilities to jointly construct a digital literacy education platform. This cross-sectoral collaborative mechanism is designed to synergistically enhance new farmers' capacity to apply digital technologies and bolster their overall information literacy. The model emphasizes deep, sustained collaboration between rural and educational stakeholders across the entire process, from needs assessment and curriculum development to instructional delivery and outcome evaluation.

2.2 Theoretical Foundation

2.2.1 Collaborative governance theory

The theory of collaborative governance originated from the philosophy of synergy and subsequently matured within the field of public administration. It emphasizes the consensus-oriented, joint participation of multiple stakeholders in the decision-making and management of public affairs [24]. This paper contends that the core tenets of collaborative governance-namely, the equal participation of diverse stakeholders, collective decision-making, and the shared realization of public goals-provide a robust framework for delineating responsibilities and fostering collaborative empowerment within the Rural-School Collaboration model. In this arrangement, the government provides policy leadership and funding, educational institutions are responsible for curriculum development and instructional delivery, rural entities manage needs assessment and logistical support, and new farmers participate as both learners and industry practitioners. The non-linear, iterative nature of collaborative governance precisely explains the model's inherent capacity for self-optimization during ongoing operations, thereby fostering a sustainable, long-term empowerment mechanism.

2.2.2 Lifelong education theory

Systematically proposed by Paul Langevin, lifelong education theory posits that education should span the entirety of the human lifecycle, characterized by continuity, inclusivity, and flexibility [25]. This paper argues that enhancing new farmers' digital literacy is fundamentally a lifelong learning endeavor; the iterative and rapid evolution of digital technologies necessitates a dynamic, ongoing approach to training rather than isolated, one-time interventions. Lifelong education theory underpins the shift of the Rural-School Collaboration model from episodic training to continuous, dynamic empowerment. This is achieved through the design of tiered curricula for diverse groups-for instance, focusing on live-streaming operations for younger farmers while emphasizing foundational digital tools for middle-aged and elderly participants. Furthermore, the utilization of online platforms facilitates flexible learning scenarios, such as systematic learning during the off-season and fragmented learning during busy farming periods, thereby establishing a closed-loop process of needs assessment-curriculum development-practical guidance-outcome feedback. This ensures that digital literacy enhancement remains aligned with evolving industry demands.

2.2.3 Digital divide theory

The conceptualization of the digital divide has evolved from an initial focus on the access gap to encompass a usage gap and, ultimately, an outcome gap [26]. This paper posits that new farmers encounter significant disparities across all three dimensions: technology access, skill utilization, and value realization. Digital divide theory provides a critical analytical lens for diagnosing the underlying causes of digital literacy deficits among new farmers and, crucially, highlights the targeted value

proposition of the Rural-School Collaboration model. The model aims to narrow the usage gap by enhancing digital skill proficiency through specialized educational interventions and to bridge the outcome gap by facilitating the conversion of acquired skills into tangible economic benefits through practice integration and alignment with industry needs. This model thus holds substantial theoretical and practical significance for mitigating the multifaceted digital divide confronting new farmers and for establishing a sustainable pathway for ongoing literacy enhancement.

3. Constructing a Theoretical Framework for the Rural-School Collaboration Model to Empower Digital Literacy Among New Farmers

This section aims to construct a systematic theoretical framework for empowerment through Rural-School Collaboration. This framework serves as the core conceptual model of the paper, and its internal logic adheres to a comprehensive empowerment value chain: driven by the empowerment agent, knowledge is transformed through the empowerment content system, capabilities are transferred via the empowerment vehicle, and ultimately, a sustainable operational loop is established with the support of the empowerment assurance system. These four key elements are neither isolated nor merely parallel; rather, they function in a stepwise, mutually embedded progression along the logical sequence of who empowers→what is used to empower→how empowerment is transmitted→how empowerment is ensured.

As illustrated in Figure 1, the intrinsic logical relationships among the four core elements can be summarized as follows: The empowerment agents (rural communities, educational institutions, government bodies, and new types of agricultural business entities) constitute the driving force of the entire model. Through the strategic complementarity of resources and a collaborative division of labor, they pool their respective assets-including practical settings, professional expertise, policy support, and market intelligence-to establish the foundational starting point of the empowerment process. These pooled resources subsequently undergo knowledge transformation within the empowerment content system (structured as a three-tiered progression: foundational, specialized, and distinctive). This transformation systematizes disparate resources and fragmented needs into structured, teachable, and actionable curriculum content. Subsequently, capability transfer is effectuated through empowerment platforms (integrating both offline and online channels), converting curricular knowledge into digital skills that new farmers can readily acquire and apply in practice. The entire empowerment process is sustained and stabilized by the empowerment support system (a three-dimensional framework encompassing policy, resource allocation, and institutional mechanisms), with the ultimate aim of achieving the core objective: enhancing the digital literacy of new farmers. Concurrently, the value creation and broader ripple effects generated by this enhanced literacy feed back into the regional rural digital ecosystem, catalyzing new cycles of demand and innovation that are subsequently relayed back to the empowerment agents, thereby initiating a new iteration of the empowerment cycle.

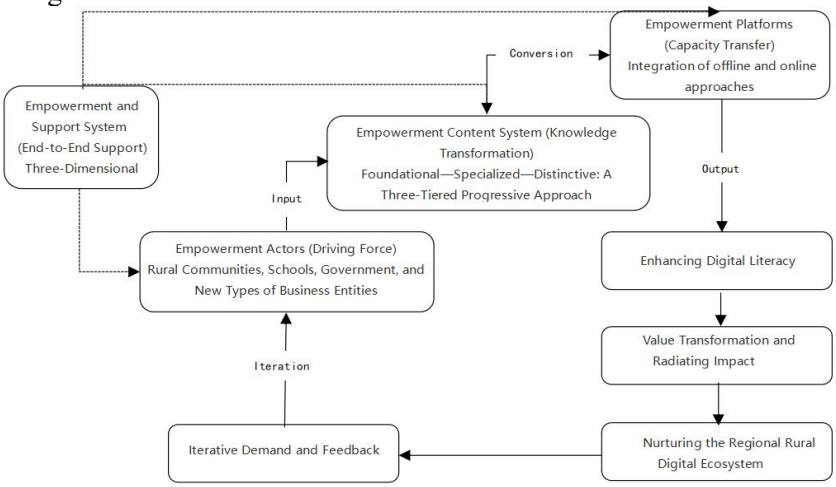

Figure 1. Framework for Empowering New Farmers' Digital Literacy through the Rural- School Collaboration Model

This framework transcends the traditional static model of merely listing elements. It integrates four key components into a complete empowerment value chain spanning from resource aggregation to

knowledge transformation, capacity transfer, and ultimately, value creation. A dynamic, closed-loop relationship of input-transformation-output-feedback is established among these stages.

3.1 Framework Construction Principles

3.1.1 Principle of resource complementarity

The principle of resource complementarity is foundational to the Rural-School Collaboration model, centering on the precise alignment of rural practical resources with academic professional resources. Rural areas offer tangible assets such as authentic production environments, hands-on operational needs, and local practitioner expertise, yet they often lack systematic professional guidance and pedagogical structure. Conversely, educational institutions possess knowledge-based assets, including specialized digital technology curricula, expert faculty, and advanced teaching facilities, but may lack access to authentic, real-world training sites and context-specific challenges. At the operational level, deliberate efforts must be undertaken to integrate these two resource streams, ensuring that digital literacy training is firmly rooted in an authentic agricultural environment. This integration facilitates the fusion of theory and practice, thereby enhancing the relevance, applicability, and overall effectiveness of the empowerment initiative.

3.1.2 Principle of demand-driven orientation

The demand-driven principle is crucial for ensuring the model's efficacy, mandating that both the content and the process of empowerment directly address the most pressing needs of individual new farmers and align with the developmental imperatives of regional agricultural industries. At the micro level, this involves a focused analysis of specific digital literacy gaps among new farmers, such as challenges related to customer acquisition and retention in e-commerce operations. At the macro level, the focus broadens to encompass the strategic objectives of the Digital Village Strategy and local industrial planning, including, for instance, the digital marketing of regional public brands. A standardized and actionable mechanism for needs assessment and diagnosis must be institutionalized, with designated representatives from both rural and educational entities coordinating regularly to translate dispersed, practical concerns into clearly defined instructional objectives. This mechanism allows for dynamic adjustment of curricula to ensure a continuous and robust alignment between the supply of training and the demand for skills.

3.1.3 Principle of collaborative efficiency

The principle of collaborative efficiency focuses on optimizing the organizational and managerial effectiveness of the model's operation. By clearly delineating the rights, responsibilities, and expectations of all participating parties-including government agencies, educational institutions, rural communities, and new agricultural business entities-a stable and efficient collaborative mechanism can be established, thereby minimizing transaction costs and mitigating the risk of internal resource wastage. Key elements underpinning this principle include: explicit role definitions and a precise demarcation of duties; streamlined operational workflows with institutionalized communication channels to ensure seamless information flow; and the articulation of unified, overarching action goals that consolidate the efforts of all stakeholders around the central objective of enhancing the digital literacy of new-generation farmers. This approach facilitates a transformation of the collaborative dynamic from one that is ad-hoc and loosely coupled to one that is routine, institutionalized, and capable of maximizing synergistic benefits.

3.1.4 Principle of sustainability

The sustainability principle is paramount to ensuring the long-term viability and impact of the model. It emphasizes that empowerment is an enduring, ongoing process rather than a short-term, finite project, necessitating a foundation built upon institutionalized mechanisms, dynamically evolving content, and the cultivation of intrinsic motivation among participants. This principle can be operationalized by: solidifying collaborative partnerships through formal institutional design, such as the execution of long-term cooperation agreements; establishing routine evaluation and feedback mechanisms to facilitate iterative refinement of teaching content in response to evolving capabilities of new farmers and shifts in the technological and market landscape; and designing equitable benefit-sharing arrangements that ensure all participating parties derive tangible value from the collaboration, thereby sustaining their long-term engagement and commitment. Such measures enable the model to function as a self-evolving system, capable of continuous adaptation to changing environmental conditions and ensuring the delivery of long-term, stable empowerment outcomes.

3.2 Analysis of Core Elements in the Theoretical Framework

Consistent with the logic of the empowerment value chain outlined above, the four core elements do not

operate in isolation but function as interconnected, organic components, each fulfilling a distinct and indispensable role within the overall value creation process.

3.2.1 Empowerment agents: the power source of the value chain

The empowerment agents occupy the foundational starting point of the value chain, serving as both the primary resource providers and the essential driving force behind the entire empowerment process. Through a collaborative division of labor, the four key categories of agents-rural communities, educational institutions, government bodies, and new agricultural business entities-infuse their unique resource endowments into the value chain: rural communities contribute authentic practical settings and real-world needs assessments; educational institutions provide specialized knowledge and structured curriculum systems; government agencies furnish policy guidance and financial support; and new agricultural business entities inject critical market intelligence and offer entrepreneurial incubation support. The specific roles and functions of each agent are detailed in Table 1.

Table 1. Roles and Functions of Empowerment Agents in the Rural-School Collaboration Model

Entity Type	Core Role	Key Features
Rural Actors	Needs Integrator, Practice Facilitator	Screening participants, consolidating and refining needs, providing authentic practical settings
School Role	Curriculum Developers, Instructors	Transforming general digital knowledge into teaching content relevant to actual production
Government Entities	Supporters, coordinators, and guarantors	Provide policies, funding, and platforms; establish evaluation mechanisms
New types of agricultural business entities	Market connectors and business incubators	Provide industry-specific practical guidance, bridge market needs, and offer employment and entrepreneurship support

Rural entities assume the core functions of participant selection, needs identification, and practical support facilitation. Their role extends beyond merely providing physical venues and a pool of trainees; it involves the organic synthesis and refinement of dispersed, individual needs into coherent training priorities, and the provision of real-world practical settings essential for the effective application and validation of acquired knowledge.

Educational institutions are entrusted with the responsibility of delivering systematic and pedagogically sound educational programs. Their core function is to translate cutting-edge, generalized digital knowledge into actionable teaching content that is directly relevant to the practical production challenges faced by new farmers. This involves deploying qualified faculty from relevant disciplines to deliver instruction and provide mentorship, thereby ensuring that new farmers can effectiv8ely assimilate and apply the knowledge. Moreover, schools should actively embrace the role of curriculum innovators, moving beyond the traditional model of unidirectional knowledge transfer to develop specialized courses-in areas such as agricultural e-commerce and data analytics-that are tailored to the specific characteristics of China's agricultural landscape and the cognitive habits of new farmers, while stimulating innovative applications throughout the instructional process.

Government entities fulfill a multifaceted role within this collaborative ecosystem, acting as supporters, coordinators, and guarantors. First, they provide the necessary policy impetus by enacting targeted support measures that clarify the strategic direction of the collaboration and ensure stable financial subsidies for Rural-School Cooperation initiatives, thereby mitigating the initial costs and risks borne by other partners. Second, they leverage their convening authority and organizational capacity to proactively establish communication and collaboration platforms, such as regular joint meetings involving schools, rural communities, and enterprises. This helps to promptly resolve issues stemming from ambiguous responsibilities or suboptimal resource allocation, ensuring the smooth and efficient functioning of the collaborative framework. Third, beyond the initial promotion phase, the government plays a crucial role in guiding all stakeholders to pool resources and establish robust evaluation mechanisms to monitor and assess the effectiveness of training outcomes, thereby safeguarding the healthy and sustainable operation of the model over the long term.

New types of agricultural business entities serve as the essential nexus linking the training ecosystem to the broader market, fulfilling three critical functions. First, they provide practical, industry-relevant guidance by deploying technical personnel or experienced managers to conduct on-site instruction, thereby sharing cutting-edge market trends, real-world case studies of successful digital technology application, and insights into practical operational risks and mitigation strategies. Second, they function as a vital feedback conduit, channeling

frontline market requirements-pertaining to agricultural product quality, packaging standards, and brand storytelling-back to educational institutions. This feedback loop enables dynamic adjustment of curricula to more precisely align with evolving market demands and enhances the overall practicality and relevance of the training provided. Third, they serve dual roles in facilitating job placement and fostering entrepreneurial incubation: offering internships and direct employment opportunities to outstanding program graduates, while simultaneously providing targeted support in areas such as product development, distribution channel access, and brand building to those trainees with demonstrable entrepreneurial potential. This comprehensive support structure assists new farmers in converting their newly acquired digital skills into tangible and sustainable economic returns.

3.2.2 Empowerment content system: the knowledge transformation layer of the value chain

The Empowerment Content System integrates upstream resources to facilitate the critical transformation from disparate resources to structured, actionable knowledge. This transformation adheres to the objective developmental trajectory governing the skill acquisition of new-generation farmers, forming a three-tiered progressive structure characterized as Foundational-Specialized-Distinctive (see Figure 2). The foundational tier addresses the entry-level imperative of whether one can use it; the specialized tier targets the core question of whether one knows how to use it effectively; and the distinctive tier addresses the competitive challenge of how well and how innovatively one uses it. These three tiers exhibit a clear progressive relationship of laying the foundation-strengthening core competencies-cultivating excellence, with mastery at each level serving as a prerequisite for successful progression to the next, thereby collectively constituting a comprehensive and coherent knowledge transformation pathway.

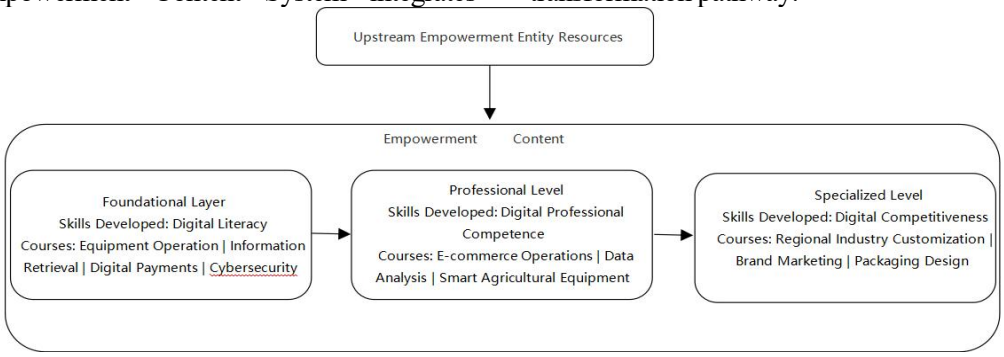

Figure 2. Three-Tiered Progressive Structure of the Empowerment Content System: Foundational-Specialized-Distinctive

Foundational Level: This level is dedicated to strengthening new farmers' foundational digital literacy, with instructional content specifically designed to eliminate barriers to everyday technology use and foster basic digital inclusion. It primarily targets new farmers who possess little to no prior digital experience or whose foundational skills are weak. The emphasis is on imparting fundamental competencies, including the operation of smart devices, effective internet-based information retrieval and evaluation, the utilization of digital payments and online financial tools, and the cultivation of robust cybersecurity awareness and personal privacy protection practices. The overarching goal of this tier is to ensure that all new farmers can successfully access and safely navigate the essential services and opportunities afforded by a digital society.

Specialized Level: This level focuses on cultivating new farmers' digital professional competencies, with course design directly aligned with critical functional areas of agricultural production and management. It is intended for new farmers who have already attained foundational digital proficiency and are seeking to enhance their operational efficiency and productivity. Core curricula include practical modules in agricultural e-commerce operations, agricultural data monitoring and analysis, and hands-on training in the use of smart agricultural equipment. Specifically, the agricultural e-commerce operations course encompasses the complete value chain, from initial store setup, product photography and display, and live-streaming sales techniques to post-sales customer relationship management. The agricultural data analysis course provides instruction on the interpretation and application of environmental sensor data and market trend analytics. The smart agricultural equipment training focuses on building operational and basic maintenance proficiency with advanced tools such as unmanned aerial vehicles (UAVs) for crop monitoring and automated smart

irrigation systems.

Distinctive Level: This tier is strategically oriented toward building new farmers' unique digital competitiveness and fostering product and process differentiation. Curriculum development at this level is closely aligned with the specific resource endowments and strategic priorities of local industries. Its aim is to empower new farmers who already possess advanced professional digital skills to pursue differentiated development pathways. Instructional content is highly customized based on the region's leading industries or unique specialty agricultural products. For instance, in the case of a geographically indicated premium product like Jinggang Pomelo, a comprehensive digital branding curriculum could be designed. This might encompass modules on brand narrative development, culturally resonant packaging design, targeted short-video marketing strategies, and high-end market positioning and channel development. Such an approach deeply integrates advanced digital skills into the local industrial value chain, thereby empowering regional agricultural branding initiatives and facilitating value enhancement.

3.2.3 Empowerment vehicle: the capability transfer layer of the value chain

Structured knowledge, once refined and codified through the content system, must be effectively delivered to new farmers via appropriate vehicles to bridge the last mile between knowing and doing. Empowerment vehicles constitute the capability transfer layer, ensuring both the breadth of knowledge dissemination and the depth of experiential learning through a strategically integrated dual-channel model that synergizes offline and online delivery modalities.

Offline platforms leverage rural physical production environments and specialized teaching spaces within educational institutions. Through active participation in on-site instruction at practical training bases-such as actual farm fields, cooperative processing facilities, and village-level e-commerce service stations-and engagement in simulated operational exercises and skill drills within school-based training centers, new farmers benefit from intuitive, hands-on, and immersive learning experiences. These experiences are crucial for internalizing theoretical concepts and translating them into readily applicable practical skills.

Online platforms, conversely, transcend the temporal and spatial limitations inherent in offline instruction. They achieve this through the deployment of Massive Open Online Course (MOOC) platforms and live-streaming instructional systems established under the leadership of educational institutions, as well as through the cultivation of online communication communities-such as dedicated WeChat groups and specialized mobile applications-that are jointly managed by rural communities and schools. This digital infrastructure provides new farmers with an extensive repository of course resources that can be reviewed asynchronously, enables real-time interactive remote instruction, and fosters ongoing peer-to-peer support and collaborative problem-solving. This approach effectively accommodates the need for flexible, just-in-time learning opportunities, particularly during peak agricultural seasons when time is fragmented.

Offline and online platforms are not mutually exclusive but function as complementary and synergistic components of a holistic capability transfer system. Offline platforms address the essential depth of learning by doing, while online platforms address the expansive breadth of learning anytime, anywhere. Together, they form a comprehensive, multi-dimensional network for skill acquisition and knowledge transfer that is both pervasive and adaptable.

3.2.4 Empowerment support system: the support system of the value chain

The empowerment support system does not directly participate in the primary, value-adding processes of the empowerment value chain; rather, it functions as a foundational enabling framework that permeates the entire system, providing the essential prerequisites for the smooth and reliable operation of the power source-knowledge transformation layer-capability transfer layer continuum. Policy support addresses the fundamental questions of legitimacy and motivation (i.e., whether it can be done). Resource support addresses the material basis for action (i.e., what is available). Institutional support addresses the regulatory and procedural order (i.e., how to operate in a standardized and accountable manner). These three dimensions of support are mutually reinforcing and collectively ensure the stability, predictability, and long-term sustainability of the empowerment value chain.

Policy safeguards constitute a prerequisite for the initial launch and subsequent scaling of the model. They necessitate that local governments formulate actionable and precisely targeted support policies. Such policies might include formally incorporating training programs for new farmers within the scope of regular fiscal subsidies or providing preferential project opportunities and formal recognition to universities and rural communities that demonstrate

active and effective participation in the collaboration. These measures collectively provide clear policy legitimacy, a stable operational framework, and the initial momentum required for sustained partnership.

Resource support serves as the indispensable material foundation for the model's ongoing operation and maintenance. It requires that all participating parties establish stable and transparent mechanisms for resource allocation and collaborative sharing. This includes a sustained commitment from universities to provide high-quality faculty and continuously updated curricula, a long-term dedication from rural communities to offer access to authentic production settings and local expertise, and a reliable pledge from government bodies to ensure consistent financial investment and, where appropriate, access to relevant data. This coordinated approach fosters a virtuous cycle of resource complementarity and shared investment.

Institutional safeguards are critical for standardizing the cooperation process and effectively managing and mitigating potential risks. This requires the formalization of collaborative relationships through legally binding Rural-School Cooperation agreements that clearly articulate the rights, responsibilities, and accountabilities of all involved parties. It also entails the establishment of a regular joint meeting system to ensure continuous, transparent, and efficient communication. Furthermore, it necessitates the implementation of a suite of supporting administrative and academic regulations-governing areas such as joint faculty development, rigorous supervision of the instructional process, and the systematic evaluation of training outcomes-to ensure that the entire empowerment process is conducted in an orderly, standardized, and fully traceable manner.

4. The Logical Framework of the Rural-School Collaboration Model for Empowering New Farmers' Digital Literacy

The process by which the Rural-School Collaboration model empowers new farmers' digital literacy adheres to a complete, interconnected, and iterative logical framework. This process commences with the identification of authentic, real-world needs, progresses through the deep synergy of resources and instructional delivery, and ultimately culminates in the achievement of sustained capability enhancement and the widespread dissemination of value and best practices.

4.1 The Logic of Needs Identification and Resource Matching: Precisely Pinpointing the Starting Point of Empowerment

The effective enhancement of farmers' digital literacy and skills hinges upon the delivery of scientific and effective training, which in turn is contingent upon a precise and nuanced understanding of the specific needs and practical challenges they face. The initial and foundational step of the Rural-School Collaboration model is the establishment of a rigorous, scientific mechanism for needs identification and resource matching. This ensures that all subsequent empowerment activities are precisely targeted and demonstrably effective. The overarching logical framework is illustrated in Figure 3.

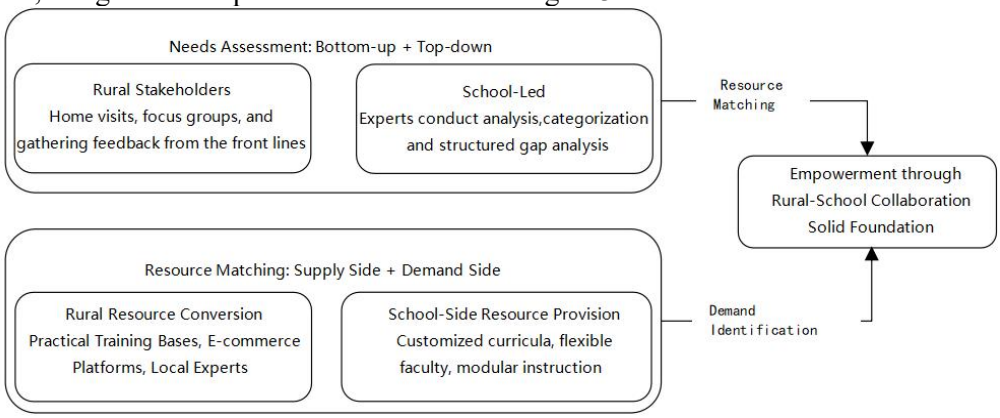

Figure 3. Logical Framework for Demand Identification and Resource Matching in the Rural-School Collaboration Model

4.1.1 Needs identification: integrating bottom-up and top-down approaches

Effective needs identification is an inherently collaborative process requiring the concerted efforts of both rural communities and educational institutions. On one hand, rural stakeholders must intensify their grassroots research and engagement efforts. Technical staff from local agricultural service centers, leaders of farmer cooperatives, and village-level officials should conduct thorough and

systematic investigations through routine household visits, structured field discussions, and thematic focus groups. The objective is to meticulously document the specific digital technology challenges that new farmers encounter in their daily production and operational activities. These challenges are often highly specific and context-dependent, manifesting as practical issues such as: an inability to effectively articulate a product's unique selling points during a live-streaming session; the acquisition of soil sensors without the corresponding capacity to interpret the data they generate; or the establishment of an online store without a clear strategy for driving customer traffic and engagement. The systematic collection and aggregation of this granular, frontline demand information constitute the preliminary, bottom-up phase of needs assessment.

Concurrently, academic institutions undertake the crucial task of further processing and refining this raw demand data. Expert teams from universities or vocational colleges engage in a professional process of organizing, categorizing, and deepening the analysis of this information. By applying analytical perspectives drawn from disciplines such as pedagogy and agricultural informatics, they are able to synthesize these scattered, practice-based issues into structured diagnoses of underlying capability gaps. These diagnoses are then strategically aligned with the broader macro-level objectives of the Digital Rural Strategy. For instance, the challenge of inability to highlight product selling points might be diagnostically attributed to insufficient capacity in digital creative expression, while the difficulty in interpreting sensor data would be characterized as a deficit in foundational data literacy. Through this analytical process, and by further integrating insights into emerging trends in smart agriculture, the core instructional objectives for a given round of empowerment are precisely defined and prioritized. This integrated needs identification mechanism, which combines bottom-up empirical data collection with top-down strategic analysis, ensures that the resulting empowerment goals are both firmly grounded in practical reality and strategically forward-looking.

4.1.2 Resource matching: efficient coupling of supply and demand

At the resource matching stage, the central objective is to achieve an efficient and dynamic coupling between the supply of available resources and the identified demand for skills. Once a clear, prioritized inventory of needs has been established, rural stakeholders must systematically organize and, where necessary, repurpose local practical assets to align with these requirements. For example, standardized production bases operated by cooperatives can be effectively repurposed as practical training and demonstration sites for new farmers. Village-level e-commerce service stations can serve as accessible platforms for the direct application and refinement of newly acquired digital skills. Furthermore, local large-scale farmers or returning young entrepreneurs who have demonstrated demonstrable success in applying digital technologies can be formally recruited to serve as local expert mentors or adjunct instructors. These localized resources are characterized by their authenticity, accessibility, and strong demonstrative impact, providing new farmers with highly relevant and immediately applicable learning benchmarks.

Simultaneously, educational institutions should prioritize the precise customization of curricula and the flexible deployment of teaching staff in direct response to the articulated needs. For example, to address the specific practical demands of agricultural e-commerce operations, they should develop a comprehensive curriculum system encompassing practical modules on agricultural product photography and videography, short video content creation and editing, live-streaming scriptwriting and performance techniques, and post-sales customer relationship management. Additionally, they should strategically assign e-commerce faculty or experienced new media operations mentors who possess both robust theoretical knowledge and substantial practical field experience to undertake the corresponding teaching and mentorship responsibilities. The successful execution of this phase hinges on the establishment of an efficient and transparent demand-resource matching platform or coordination mechanism, which is essential for resolving structural misalignments between supply and demand. By accurately identifying needs and effectively orchestrating the alignment of resources, a solid and durable foundation for the entire empowerment initiative is established.

4.2 The Logic of Synergistic Teaching and Practice Integration: The Core Empowerment Process

The effective cultivation of new farmers cannot be divorced from either the research insights of agricultural institutes or the operational realities of the agricultural production frontline; indeed, it must be carried out in close and continuous coordination with both [27]. Building upon the foundation of

matched demand and resources, the Rural-School Collaboration model progresses to its core empowerment phase. This stage is dedicated to facilitating a critical and transformative transition in new farmers' digital literacy-moving from passive theoretical comprehension to active behavioral change, and from abstract knowledge acquisition to the confident and competent application of practical skills. This transition is achieved through the deliberate and systematic integration of collaborative teaching methodologies and immersive, hands-on practical experience.

4.2.1 Collaborative teaching: the school instruction + rural guidance dual-track model

The collaborative teaching phase adopts a School-Based Instruction + Rural Guidance dual-track model, which is specifically designed to overcome the persistent pedagogical disconnect often observed between abstract theoretical instruction and context-specific practical guidance. Within this model, instructors from educational institutions focus on the systematic and coherent transmission of the fundamental principles and conceptual frameworks underpinning digital technologies. This includes instruction on topics such as the algorithmic logic governing e-commerce platforms, fundamental data analysis methodologies, and the operational principles of Internet of Things (IoT) sensors. This ensures the systematic rigor and scientific validity of the knowledge base being imparted. Concurrently, rural-based mentors leverage authentic, real-world production scenarios to provide concrete application demonstrations, hands-on technical coaching, and the sharing of tacit, experience-based knowledge. They offer actionable guides that are immediately relevant and directly implementable in the local context. These two instructional streams are not merely juxtaposed or sequentially presented; rather, they are deeply and iteratively interwoven throughout the learning process. Following a theoretical exposition by a school-based instructor, a rural mentor guides the trainees in observing, analyzing, and applying the concepts within their immediate local environment, often conducting spontaneous, on-site demonstrations in the field or within a live-streaming studio. This dual-track, theory-practice alternating pedagogical model significantly enhances the transferability and applicability of the learning outcomes.

4.2.2 Integration of practice: from knowing to being able to use to using effectively

Practical integration constitutes the essential pathway for testing, validating, and consolidating learning outcomes. Its core focus is on guiding new farmers to synthesize and comprehensively apply their newly acquired skills within the context of real-world, industrially relevant tasks and projects. This model actively designs and facilitates a variety of structured, hands-on learning experiences. Examples include: conducting collaborative, joint live-streamed sales events featuring local agricultural products (encompassing the entire process from initial product selection, pricing strategy, and script development to the final live-stream execution and post-event analysis); organizing smart agriculture technology application competitions (for instance, challenging participants to optimize irrigation schedules based on real-time sensor data analysis); or tasking teams with developing comprehensive digital promotion strategies for regional public agricultural brands (integrating multiple communication channels such as short video platforms, social media campaigns, and e-commerce storefront optimization). Throughout the lifecycle of these practical projects, a joint guidance team composed of university faculty and local mentors provides comprehensive, wrap-around support to the trainees. They offer timely answers to emerging questions, provide corrective feedback and strategic course adjustments, and facilitate access to necessary resources and networks. Through this structured process of learning by doing, new farmers not only deepen their conceptual understanding of underlying theories but also actively hone their problem-solving abilities and adaptive expertise within complex and dynamic real-world agricultural scenarios. This process ultimately drives a substantive and qualitative transformation of their digital literacy-progressing from a state of simply knowing to one of being able to use, and finally to one of mastering the skills with confidence and fluency.

4.3 Feedback and Optimization-The Logic of Skill Enhancement: Achieving Continuous Empowerment

The Rural-School Collaboration model is not a linear, unidirectional, or closed-loop process; rather, it is a dynamic and self-regulating cyclical system equipped with robust feedback and iterative optimization mechanisms. This inherent logic ensures that the outcomes of the empowerment process are both assessable and traceable, and it enables the system to engage in autonomous self-adjustment in response to evolving internal dynamics and shifting external conditions. This capacity for self-correction is what drives the

continuous evolution and sustained enhancement of new farmers' digital literacy over time.

4.3.1 Feedback and optimization: establishing an assessment-feedback-optimization closed-loop

Feedback and optimization constitute a critical and indispensable mechanism for driving the continuous improvement of new farmers' digital literacy. By establishing a dynamic and multi-faceted evaluation and feedback system, the actual effectiveness of the digital literacy enhancement initiatives can be systematically verified and monitored. This is operationalized through the implementation of a diverse array of assessment methods, including targeted skills tests (e.g., successfully listing a new product on an online store within a specified timeframe), practical performance evaluations (e.g., independently planning and executing a live-streamed sales event and accurately recording key performance metrics such as sales volume and audience engagement), and periodic satisfaction surveys administered to participating new farmers. Key quantitative performance indicators might include metrics such as total online sales volume of agricultural products, e-commerce store traffic analytics, and customer conversion and retention rates. Rural communities and educational institutions should jointly organize regular, structured feedback and review meetings to facilitate the timely analysis of evaluation data. These sessions should be used to make prompt, data-informed adjustments to both the content and the delivery methods of the training. For instance, if evaluation data reveals that a significant cohort of trainees is experiencing persistent difficulties with short-form video editing, a specialized supplementary workshop should be promptly developed and integrated into the curriculum. Conversely, if the data indicates that practical, hands-on training comprises less than 40% of the total instructional time and is correlated with suboptimal skill acquisition, the proportion of applied, hands-on instruction should be commensurately increased. This iterative process establishes a robust closed-loop operational model of evaluation-feedback-optimization, which serves to ensure that the empowerment content remains consistently and tightly aligned with the evolving practical needs of the learners.

4.3.2 Skill advancement: from basic operations to innovative applications

As the digital literacy of new-generation farmers undergoes progressive improvement, the rural revitalization empowerment model must undergo corresponding and continuous deepening and expansion. In terms of content, a deliberate and structured leap must be facilitated, moving from basic digital operations and functional proficiency toward the innovative and strategic application of advanced digital technologies. This progression involves the introduction of more sophisticated and cutting-edge topics, such as agricultural big data analytics (e.g., the development and interpretation of crop yield prediction models, and the analysis of market price trends and volatility) and Internet of Things (IoT)-enabled remote monitoring and control systems (e.g., the regulation of greenhouse environmental parameters via mobile device applications). In terms of broader competency development, the focus must shift from the cultivation of isolated, single-skill proficiencies toward the nurturing of comprehensive digital business management acumen. This entails the development of a multi-disciplinary knowledge base that integrates digital brand strategy for agricultural products, the fundamentals of agricultural supply chain finance, and the operational intricacies of cross-border agricultural e-commerce. This structured pathway for capability advancement is strategically designed to equip new farmers with the higher-order skills necessary to adapt to the increasingly sophisticated requirements of the Digital Rural Strategy. Through the ongoing optimization of the empowerment system, a virtuous and mutually reinforcing cycle is cultivated between the continuous enhancement of individual competencies and the dynamic evolution of the overarching strategic framework. For example, a new farmer who has successfully completed training at both the foundational and professional levels may subsequently be eligible to enroll in an advanced Digital Agriculture Leader program. This advanced program would focus on imparting higher-level strategic skills, such as data-driven decision-making for farm management and the formation and leadership of effective online marketing teams.

4.4 Value Transformation-Radiation and Driving Logic: Amplifying the Empowerment Effect

Value transformation and its subsequent radiation and driving effects constitute the culminating and catalytic components of the Rural-School Collaboration model's approach to empowering digital literacy. This process encompasses both the individual-level application of knowledge and the creation of tangible economic value, as well as the broader, regional-level coordinated development that is propelled by the organic diffusion and social

multiplication of newly acquired skills.

4.4.1 Value transformation: from digital literacy to economic benefits

Value transformation is manifested in the ability of new farmers to effectively and strategically deploy their enhanced digital literacy across the entire spectrum of agricultural production and management activities, thereby achieving a substantive and measurable shift from abstract knowledge acquisition to the generation of concrete economic benefits. During the cultivation phase, the application of digital technologies-such as smart environmental sensors and drone-assisted precision crop protection-enhances production accuracy and optimizes resource utilization efficiency, while simultaneously reducing input costs and minimizing environmental impact. In the sales and marketing phase, the utilization of e-commerce platforms, live-streaming sales channels, and targeted community marketing strategies expands market reach, improves the overall efficiency of agricultural product distribution, and disintermediates traditional supply chains to capture greater value at the farm gate. In the management and administration phase, digital tools are employed for more precise cost accounting, efficient inventory management, and the systematic cultivation and maintenance of customer relationships. Ultimately, this holistic integration of digital capabilities drives significant growth in individual and household income and contributes substantively to the broader digital transformation of the agricultural sector as a whole. This process thereby completes a closed-loop transition from enhancing digital literacy to creating tangible agricultural value, serving as a powerful and practical demonstration of the contribution of digital empowerment to the broader goals of rural revitalization. For example, a trainee who participated in a Rural-School Collaboration program successfully pivoted from a reliance on traditional offline sales channels to an integrated, multi-channel model incorporating short videos + livestreaming + online store. Within a period of six months following the training, this individual's online sales revenue increased by over 300%, and the initiative also facilitated the integration of five neighboring farming households into the new digital sales framework.

4.4.2 Radiating impact: from individual mastery to collective benefits

The radiating impact and broader ripple effects of the model are generated through a mechanism that relies on a cohort of early-adopter new farmers who have already attained a high level of digital proficiency. Through structured mentorship and peer-to-peer assistance arrangements, these individuals serve as catalysts for disseminating digital skills and operational best practices to neighboring farmers and the wider community. Typical practices that operationalize this radiating effect include: formally inviting outstanding program graduates to serve as Rural Digital Instructors and tasking them with organizing small-scale knowledge-sharing sessions and workshops during the agricultural off-season; establishing structured one-to-many paired assistance mechanisms, whereby each highly proficient new farmer is formally assigned to mentor and support a small cohort of three to five neighboring farmers; and setting up walk-in Digital Consultation Stations at village-level e-commerce service hubs, staffed on a rotating basis by core program trainees to provide accessible, on-demand answers to common operational questions. The specific topics addressed through these diffusion mechanisms are highly practical and context-relevant, including guidance on basic e-commerce platform management techniques, troubleshooting of smart device operation and maintenance issues, and the dissemination of effective solutions to common challenges encountered in digitally-enabled production environments. This demonstration and peer-promotion effect-captured in the principle of one person masters the skills, and many in the community benefit-effectively lowers the overall perceived and actual barriers to digital technology adoption in rural areas. It facilitates the gradual but steady construction of a widespread, multi-tiered, and resilient network of rural digital talent, thereby establishing a firm and sustainable social foundation for the long-term and equitable advancement of digital rural development initiatives.

5. Conclusions and Outlook

5.1 Research Conclusions

Centered on the pressing practical need to enhance the digital literacy of new farmers within the framework of the Digital Village Strategy, this study has systematically constructed the theoretical framework and elucidated the logical rationale underpinning the Rural-School Collaboration empowerment model. The research concludes that this model is comprised of four essential and interconnected elements: the empowerment agents, the content system, the empowerment platforms (or vehicles), and the support system. The model's internal logic adheres to a coherent value chain

structure defined by the sequence of who empowers-what is used to empower-how empowerment is delivered-how empowerment is ensured, thereby forming a cohesive, progressive, and organic system. Its operational logic unfolds in a four-part sequential process: needs identification and resource matching serves as the precise and foundational starting point; collaborative teaching and practice integration constitutes the core pedagogical and experiential component; feedback optimization and capability upgrading provides the essential dynamic and driving force for long-term sustainability; and value transformation and radiation-driven promotion represents the ultimate objective and culminating impact of the model. These four logical phases are deeply interconnected and function in a continuous, cyclical manner, thereby constituting a complete and dynamic loop of empowerment. This model effectively and strategically integrates the rich practical contexts of rural communities with the specialized professional resources of educational institutions. In doing so, it offers a viable and robust pathway to address the current challenges that beset digital literacy education for new farmers-namely, the persistent mismatch between the supply of training and the demand for skills, the fragmentation of available educational resources, and the chronic weakness of practical, hands-on training components. The model therefore holds significant theoretical value and considerable practical import for advancing the construction of digital villages and for revitalizing the pool of rural talent.

5.2 Research Limitations and Future Prospects

The theoretical framework articulated in this study has not yet been subjected to large-scale, systematic empirical validation in diverse field settings. Its adaptability, robustness, and overall effectiveness across a range of regional contexts-for example, the contrasting socio-economic and infrastructural conditions of eastern versus western regions of China-and within various agricultural sub-sectors-including crop cultivation, animal husbandry, and agritourism enterprises-remain to be rigorously tested and verified through subsequent empirical research. Furthermore, the study's exploration of the potential integration mechanisms for more advanced and emerging frontier technologies, such as artificial intelligence, machine learning, and blockchain-based traceability systems, remains relatively preliminary and underdeveloped. Future research endeavors should prioritize the selection of diverse and representative pilot regions in which to conduct in-depth empirical analyses to test, refine, and optimize the proposed theoretical framework. Researchers should actively and proactively investigate the potential for deep and synergistic integration of intelligent technologies-such as agricultural big data platforms, immersive virtual simulation environments, and AI-powered personalized tutoring and decision-support systems-with the operational architecture of the Rural-School Collaboration model. Moreover, future work should focus on the development of highly modular and adaptable curriculum systems that are specifically tailored to the distinct needs and characteristics of different sub-groups within the broader new farmer demographic. This includes large-scale crop growers, intensive livestock farmers, returning young entrepreneurs with varying educational backgrounds, and specialized e-commerce practitioners. The objective is to achieve an even greater degree of precision and efficiency in competency enhancement, thereby providing a more solid, dynamic, and enduring talent foundation for the comprehensive and sustainable construction of digital rural communities.

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