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Empowering Rural Education Revitalization with Data-Intelligent Technologies in the Context of Building a Leading Educational Power: Theoretical Underpinnings, Critical Barriers, and Practical Pathways

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Abstract

The persistent urban-rural education gap remains a critical challenge for achieving educational equity and sustainable development in developing countries. Within the framework of building a leading educational power, revitalizing rural education is not merely a policy priority but a fundamental pathway to interrupting intergenerational poverty and fostering social mobility. Against the backdrop of building a leading education power and advancing rural revitalization, data-intelligent technologies serve as both a bridge narrowing the urban-rural educational divide and a critical engine for propelling rural education revitalization. This empowerment process is underpinned by a four-dimensional theoretical framework that provides essential support for its development. However, in the transitional journey from a large education country to a leading education power, the application of these technologies confronts four critical barriers: the misalignment between technological adaptation and rural contextual needs, the imbalance between cost investment and resource distribution, the deficiency in digital literacy and competence, and the fragmentation between digital resources and indigenous rural ecosystems. To tackle these challenges, this study proposes corresponding strategies—namely, precision adaptation to resolve the technology-need mismatch, balanced investment to alleviate cost-resource disparities, capacity building to compensate for digital literacy and competence shortages, and localized resource development to remedy the disconnection between digital assets and rural settings. Collectively, these measures are intended to unlock broader possibilities for empowering rural education revitalization and thereby contribute meaningfully to the ultimate realization of the leading education power objectives.

Keywords: leading educational power, data-intelligent technologies, rural education, educational revitalization; educational equity

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1. Introduction

Rural areas constitute the foundation of Chinese society, and rural revitalization serves as the cornerstone of national strength (Wang, Jiang, Zheng, & Hu, 2020). In January 2025, the Central Committee of the Communist Party of China and the State Council jointly issued the Opinions on Further Deepening Rural Reform and Solidly Advancing Comprehensive Rural Revitalization, which articulated the central theme of deepening rural reform to promote holistic rural revitalization (State Council, 2025a). Comprehensive rural revitalization encompasses industrial revitalization, cultural revitalization, ecological revitalization, organizational revitalization, and talent revitalization (State Council, 2024). Among these, the development and advancement of rural education constitute an integral component and fundamental requirement of rural talent revitalization, while also representing a pivotal measure for eradicating poverty and achieving holistic rural revitalization (Li & Wang, 2023; Zhang et al., 2022; UNESCO, 2021). In the same month, the Central Committee of the Communist Party of China and the State Council promulgated the Planning Outline for Building a Leading Education Power (2024–2035), which explicitly mandates the use of digital technologies to reconstruct instructional scenarios, upgrade educational governance, and innovate assessment methods, thereby comprehensively empowering the integrated development of urban and rural education (State Council, 2025b).

The deepening advancement of digital technologies has given rise to data-intelligent technologies that place greater emphasis on intelligent decision-making and value creation. Data-intelligent technologies represent an

integrated application of next-generation data and intelligent technologies, comprising data (Internet of Things, sensors, and big data), computing power (cloud computing and edge computing), and algorithms (process models and artificial intelligence) (Wang, 2023). Through technological means such as data perception, storage, transmission, intelligent analytical processing, and intelligent decision-making, these technologies transcend geographical and resource constraints, providing rural students with educational opportunities comparable to those of their urban counterparts. In doing so, they effectively promote educational equity and further advance the realization of rural education revitalization objectives. As recent scholarship confirms, intelligent technologies serve as the foundation for reshaping educational paradigms through their capacity to enhance personalization, interactivity, and adaptive learning (Yang, Shi, Zhu, & Sun, 2025). Against the historical backdrop where the strategic objectives of building a leading education power and advancing rural revitalization converge, data-intelligent technologies not only serve as a bridge narrowing the urban-rural educational gap but also function as a critical engine propelling the revitalization of rural education. Nevertheless, the precise mechanisms through which data-intelligent technologies can effectively empower rural education revitalization warrant further in-depth investigation. Accordingly, this article focuses on the theoretical underpinnings, critical barriers, and practical pathways of data-intelligent technology empowerment for rural education revitalization within the context of building a leading education power, exploring the means by which such empowerment can be achieved. The aim is to provide novel theoretical support and practical strategies for the revitalization of rural education.

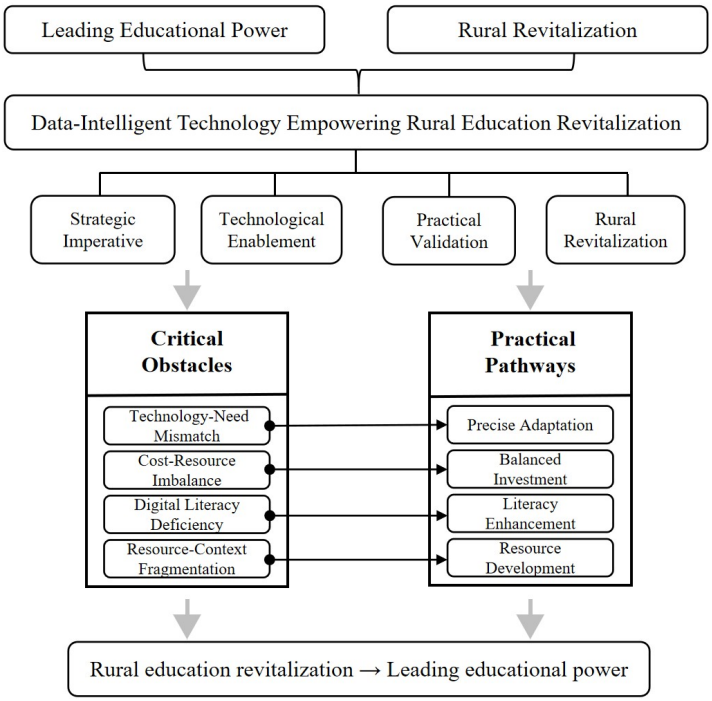

Figure 1. Analytical framework of data-intelligent technology empowerment for rural education revitalization

2. Theoretical Logic of Data-Intelligent Technology Empowerment for Rural Education Revitalization ami d the Construction of a Leading Educational Power

A strong nation must have strong rural areas; only when rural education achieves strength can the goal of building a leading educational power be fully realized (Wu, 2023). The convergence of the leading educational power strategy and the rural revitalization strategy presents a historic opportunity for rural education. However, rural education still faces deep-seated challenges, including resource scarcity and teacher shortages. Meanwhile, data-intelligent technologies represented by big data and AI are driving educational paradigm shifts, offering technical solutions to these challenges. National digital education strategies and improving rural infrastructure further reinforce the theoretical foundation for technology empowerment, ultimately contributing to the great rejuvenation of the Chinese nation (Hou & Song, 2024).

2.1 Strategic Imperative: The Inevitable Demand of National Strength Goals and Shared Prosperity Missions

Common prosperity entails the material and spiritual enrichment of all people, encompassing shared access among urban and rural populations. This requires further narrowing the development gaps between urban and rural areas and income distribution disparities to achieve inclusive development (Lai, 2023). In the grand landscape of contemporary national development, the construction of a leading educational power and the goal of common prosperity are closely intertwined, jointly constituting a vital force for advancing comprehensive social progress. The leading educational power strategy pursues "fairness with quality" as its core objective, while the current uneven distribution of urban and rural educational resources has become a bottleneck constraining educational equity and quality enhancement. Data-intelligent technologies, with their distinctive "technological equalization" characteristics, offer the possibility of breaking through geographical and resource constraints. By constructing cloud-based educational resource-sharing platforms and implementing remote instruction, data-intelligent technologies can ensure that rural students enjoy educational opportunities on par with their urban counterparts, thereby advancing educational equity from concept to practice and paving the way for the vision of "better and fairer education for all."

At the same time, common prosperity, as another critical objective of national development, depends substantially on education as a fundamental pillar of people's livelihood. Education serves as the fundamental pathway for interrupting the intergenerational transmission of poverty and plays an irreplaceable role in enhancing human capital quality and promoting social mobility. The deep application of data-intelligent technologies in rural education not only enriches instructional content and innovates teaching methods but also precisely addresses the individualized needs of rural students, enhancing their overall competencies and employability. In this process, the enhancement of human capital quality directly translates into increased social mobility, thereby reducing income disparities caused by educational inequality and vividly embodying the core principle of "sharing the fruits of development." The empowerment of rural education through data-intelligent technologies represents a strategic intersection of the leading educational power strategy and the common prosperity goal. A bidirectional empowerment relationship exists between educational equity and economic balance. Data-intelligent technologies support rural revitalization by optimizing the allocation of rural educational resources, while the common prosperity policy system provides institutional safeguards for the diffusion of technology, forming a strategic nexus that links educational modernization with coordinated regional development.

2.2 Technological Enablement: Intrinsic Mechanisms for Resource Breakthrough and Personalized Provision

In the process of rural education modernization, technological enablement serves as an intrinsic mechanism for optimizing the allocation of educational resources and providing personalized services. Through digital tools, it is restructuring the rural educational ecosystem, offering structural support for breaking through traditional resource constraints and achieving precision education services. By constructing an innovative system of "cloud-based educational resource sharing platforms + extensive access to intelligent terminals," data-intelligent technologies effectively break down geographical boundaries, enabling high-quality educational resources to be delivered to every corner of rural areas at low cost and high efficiency. In Xindu District, Xingtai City, Hebei Province, relying on the "urban-rural interconnected online education community" and underpinned by full coverage of the educational metropolitan area network, cloud-based platforms have facilitated partnerships between high-quality urban schools and rural schools. Through collaborative lesson preparation, classroom coordination, and online teaching research, rural students' academic performance has improved by 29%, and the award rate among rural teachers has increased by 38% (People's Daily Online, 2025), forming a replicable model for integrated urban-rural education. Through this model, rural students gain access to educational opportunities equivalent to those of their urban counterparts, effectively alleviating the inequitable distribution of educational resources caused by geographical disparities and laying a solid foundation for the realization of educational equity.

Simultaneously, data-intelligent technologies are deeply integrated into the instructional processes of rural education. Through the precise application of big data analytics and AI algorithms, comprehensive monitoring and dynamic assessment of students' learning conditions have become possible. This transformation enables education to move beyond the traditional "one-size-fits-all" instructional model, instead offering personalized learning plans based on individual student differences. The system can accurately identify each rural student's learning needs, interest preferences, and knowledge mastery, dynamically adjusting instructional content, methods, and pacing to ensure that every student can progress at a pace best suited to them. This data-driven,

student-centered personalized learning model not only significantly enhances rural students' learning efficiency and engagement but also stimulates their learning potential and creativity, injecting new vitality and hope for the long-term development of rural education. Through technological enablement, rural education is progressively advancing toward intelligent and precision-oriented practices, providing robust talent support and intellectual guarantees for the comprehensive revitalization of rural areas.

2.3 Practical Validation: Feasible Pathways for Cost Optimization and Model Innovation

Cost optimization and model innovation, as critical pathways for the implementation of data-intelligent technologies, are advancing through infrastructure upgrades and yielding significant and far-reaching results. By 2023, the internet access rate for primary and secondary schools nationwide had reached 100%, with 99.9% of schools having export bandwidth exceeding 100 Mbps, and over three-quarters of schools achieving wireless network coverage (Ministry of Education, 2023). This consolidation of hardware infrastructure has not only substantially reduced the threshold and cost of applying data-intelligent technologies but has also opened up vast possibilities for technology-empowered rural education. Taking Quanzhou City's "5G+ Dedicated Classroom" project as an example, this initiative constructs a government-enterprise-school collaborative mechanism, leveraging 5G networks to achieve real-time bidirectional connectivity between urban quality teachers and rural teaching sites. The project innovatively adopts a "dual-teacher + multi-school student" cloud classroom model, in which lead teachers and on-site support teachers in remote areas form a closed-loop instructional system (Chen & Huang, 2024), optimizing both the cost and efficiency of educational resource sharing. This demonstrates that infrastructure optimization can reduce the cost of technology application, thereby offering a feasible pathway for advancing educational equity.

At the level of model innovation, data-intelligent technologies have demonstrated considerable capacity for addressing the structural teacher shortages that have long plagued rural education. Through the "dual-teacher classroom" model—where urban master teachers deliver remote instruction while rural teachers provide on-site facilitation—quality teaching resources are shared across time and space, alleviating the shortage of rural teachers while improving instructional quality. At the same time, the introduction of intelligent tools such as AI teaching assistants has further optimized instructional models. For instance, Seewo has deployed AI-enabled demonstration classrooms at the Kuniushan Red Army School in Shiqian, Guizhou Province, where an intelligent feedback system generates classroom analysis reports to optimize instructional segments. Its "legacy equipment upgrade" approach renews AI capabilities in county-level classrooms at a low cost, reducing dependence on teaching staff while building precision teaching models through technological empowerment, offering a replicable pathway for reducing the burden and improving efficiency in rural education modernization (Xinhua Net, 2025). This series of model innovations not only reduces excessive dependence on traditional teaching staff and lowers labor costs but also drives the renewal of educational models through technological empowerment, opening new pathways for the revitalization of rural education.

2.4 Rural Revitalization: Dual Drivers of Talent Support and Cultural Heritage

Talent support and cultural heritage, as two core driving forces, are closely linked to the effectiveness of rural education revitalization and the deep application of data-intelligent technologies. Talent support serves as the material foundation and intellectual guarantee for rural revitalization, with the key lying in constructing a talent cultivation mechanism that meets the demands of modern agricultural development. Through big data analytics, AI algorithms, and other means, data-intelligent technologies precisely align with the needs of rural industrial upgrading, customizing educational curricula and training systems that effectively enhance the skill levels and comprehensive competencies of rural talent. This promotes the rational flow and efficient allocation of talent in emerging fields such as smart agriculture and rural e-commerce. In this process, a virtuous cycle of "education empowers talent, talent drives industry, and industry reinvests in education" is established, providing a sustained supply of talent and intellectual support for rural revitalization.

Cultural heritage constitutes the "root" of rural revitalization's strength and the "soul" of its development (Song & Wang, 2019), and its modern transformation depends on the innovative application of data-intelligent technologies. Through digital collection, storage, processing, and presentation, data-intelligent technologies enable the comprehensive integration and efficient utilization of rural cultural resources. High-definition image recording, 3D modeling and reconstruction, and other techniques allow for the permanent preservation and widespread dissemination of cultural assets such as historical sites and traditional architecture. The rise of new media platforms, including social media and short-video platforms, has provided new channels for showcasing

and promoting intangible cultural heritage, folk arts, and other rural cultural treasures, effectively enhancing the reach and influence of rural culture. For example, the Xunpu Zanhuawei (floral headdress) tradition in Quanzhou, Fujian Province, achieved cultural breakthrough through short-video platforms, creating a communication loop of "offline experience → online virality → offline spillover effects." This not only strengthens rural residents' cultural identity and pride but also injects new vitality into the integrated development of rural cultural tourism, facilitating the transformation of cultural value into economic value and providing profound cultural depth and strong developmental impetus for rural revitalization. Thus, data-intelligent technologies drive talent revitalization and precisely empower industrial upgrading, while simultaneously innovatively preserving rural culture, promoting cultural-tourism integration and economic transformation, collectively solidifying the foundations of revitalization.

Table 1. Theoretical Framework of Data-Intelligent Technology Empowerment

Dimension	Core Proposition	Key Mechanism
Strategic Imperative	National strength goals and common prosperity missions	Technological equalization; institutional safeguards
Technological Enablement	Resource breakthrough and personalized provision	Cloud-based sharing platforms; AI-driven adaptive learning
Practical Validation	Cost optimization and model innovation	Infrastructure upgrades; dual-teacher classroom models
Rural Revitalization	Talent support and cultural heritage preservation	Skill cultivation systems; digital cultural archives

3. Critical Obstacles in Leveraging Data-Intelligent Technologies for Rural Education Revitalization within the Leading Educational Power Framework

In the transitional process from a large education country to a leading educational power, data-intelligent technologies have provided essential support for rural education revitalization. The national strategy for educational digitalization has advanced steadily, and infrastructure conditions have continued to improve, laying an initial foundation for technological empowerment. However, a significant gap remains between theoretical advantages and the practical realities of rural education. Currently, the application of data-intelligent technologies in rural education faces multiple structural bottlenecks that severely constrain the depth of technology application and the transformation of its effectiveness. A recent systematic review of 67 studies on educational technology integration in rural schools similarly confirmed that the absence of a unified conceptual framework, together with limited coordination among structural conditions, instructional practices, and institutional policies, continues to impede the full realization of technology's transformative potential in these settings (Jiménez-Bernal, Boude Figueredo, & Vargas Sánchez, 2025). Therefore, it is imperative to accurately identify core points of tension, conduct in-depth analysis of key issues, and create the necessary conditions for removing barriers to technology implementation and achieving effective empowerment.

3.1 Mismatch between Technological Adaptation and Rural Contextual Needs

In the process of building a leading educational power, data-intelligent technologies should achieve deep integration and precise alignment with rural needs to fully unleash their empowerment potential. However, in practice, the application of data-intelligent technologies in rural education often fails to accurately match the unique needs of rural education, resulting in an inability to effectively transform technological resources into educational effectiveness. First, the deep rupture between the logic of technology supply and the rural educational scenario constitutes the primary contradiction. Data-intelligent technology products are typically designed with urban educational scenarios as their blueprint, and their standardized functional architectures exhibit a significant misalignment with the specialized needs of rural education. This "urban-centric" technology supply model neglects the ecological characteristics of rural education and the value of local cultural heritage, causing technological products to struggle with integration into rural educational scenarios in practical application.

Second, the temporal mismatch between the pace of technological iteration and the adaptive capacity of rural educational actors exacerbates the contradiction. The urban-dominated technological iteration model follows "Moore's Law," while the technology absorption capacity of rural education systems is constrained by practical conditions such as teacher structure and infrastructure, creating a pronounced "digital time lag." This mismatch not only leads to the waste of educational resources but also deepens educational inequality. When urban schools

have already entered the AI 2.0 application stage, rural teachers still need to expend considerable time adapting to basic technological tools. This "Matthew effect" of technological empowerment further widens the urban-rural educational gap. Finally, the potential conflict between data-driven decision-making paradigms and rural educational ethics gives rise to a value paradox. Algorithmic recommendation systems trained on urban student data may erode the cultural identity of rural students through their recommended content, while the ethical boundaries of data collection become increasingly blurred in rural contexts, heightening the risk of student privacy breaches. This divergence between technological rationality and value rationality reflects the neglect of rural educational subjectivity within the technological governance system and exposes the absence of humanistic concern in the process of technological empowerment. In summary, the core contradiction of the mismatch between technological adaptation and rural needs is essentially a systemic conflict between the standardized logic of technology supply and the particularity of rural educational scenarios. This conflict permeates every aspect of technology application, making it difficult for data-intelligent technologies to genuinely transform into a powerful driving force for advancing rural education revitalization.

3.2 Imbalance between Cost Investment and Resource Allocation

Currently, in the practice of accelerating the penetration of data-intelligent technologies into rural educational scenarios, structural contradictions in resource allocation have become a core constraint on the transformation of technological empowerment effectiveness. First, high application costs constitute a barrier to universal adoption. The introduction of data-intelligent technologies requires not only the procurement of advanced hardware but also sustained investment in software development, system maintenance, and teacher training, placing a heavy financial burden on economically disadvantaged rural areas. Some schools, in order to introduce intelligent teaching systems, have had to cut back on other basic investments, leading to fragmented technology application. This cost pressure stems from an imbalanced investment structure: fiscal resources are excessively tilted toward hardware procurement, while soft investments such as curriculum development and human resource training are seriously insufficient, creating a distorted pattern that prioritizes equipment over application.

Second, regional imbalances in allocation exacerbate the digital divide. The gap in technology application between urban and rural areas, and between different regions, shows a significant stepwise disparity. Economically developed regions leverage their resource advantages to rapidly advance digital construction, while underdeveloped rural areas face developmental difficulties due to funding shortages and technological lag. This divergence stems from an efficiency-prioritized allocation logic—technological resources are concentrated in central schools to create demonstration benchmarks, while transfer payment mechanisms fail to precisely respond to the needs of remote teaching sites, resulting in a Matthew effect where "the strong grow stronger, and the weak grow weaker." Finally, the misallocation of costs and resources constrains long-term development. High operation and maintenance costs continue to squeeze schools' basic budgets, and some educational institutions are forced to discontinue the use of technological equipment because they cannot afford maintenance expenses. The underlying crux lies in the reliance of fiscal investment on short-term project-based operations, lacking a long-term operation and maintenance budget mechanism. Coupled with the monopolistic characteristics of the technology ecosystem, rural schools are forced to make difficult choices between abandoning technology and crowding out other resources. These threefold imbalances intertwine with one another: the inversion of the investment structure undermines the efficiency of technological transformation, regional allocation disparities widen the binary division in education, and the absence of operation and maintenance safeguards distorts the essence of technological empowerment. The crowding out of soft resources by hardware investment, the gradient differentiation caused by the resource siphon effect of central schools, and the sustainability crisis resulting from the lack of maintenance mechanisms ultimately constrain the deep-rooted and long-term development of data-intelligent technologies within the rural educational ecosystem.

3.3 Deficiency in Digital Literacy and Competence

Teachers' digital literacy is a critical soft power driving the digital transformation of education (Wu, 2023). Through practical internalization and cognitive sublimation, digital literacy progressively evolves into digital competence that drives educational digital transformation. However, the current deficiency in digital literacy and competence among rural teachers has become increasingly prominent, constituting a key factor constraining the effective empowerment of data-intelligent technologies in rural education. First, weak basic operational skills create barriers to technology application. Rural teachers generally face operational difficulties in using intelligent

teaching devices, with most only being able to complete basic projection display functions, while technical operations such as device debugging and system maintenance require external support. The utilization rate of advanced functions such as intelligent grading and learning analytics remains persistently low, and there is a notable gap between the depth of technology application and the sophistication of equipment. This deficiency in basic competence stems primarily from the marginalization of technology courses in pre-service teacher education and the "theory-heavy, practice-light" tendency in in-service training, resulting in teachers' technological capacity improvement lagging behind equipment renewal.

Second, insufficient capacity for pedagogical integration constrains the depth of technological empowerment. Current technology application among rural teachers largely remains at the 初级阶段 of simply digitizing paper lesson plans, lacking the innovative capacity to reconstruct instructional processes based on technological features such as virtual experiments and data dashboards. Practical exploration in deep application scenarios such as personalized learning support and intelligent assessment is notably insufficient, with subject teaching and technology application appearing as "two separate skins." This integration dilemma reflects both the absence of interdisciplinary cultivation in teacher education and the insufficient supply of methodologies for bridging "educational technology and subject teaching" within existing training systems. Finally, the absence of digital ethics cognition raises the threshold for practical exploration. With the large-scale application of educational data, teachers generally lack systematic understanding of key issues in data-intelligent technology application, including privacy protection in data collection, cultural adaptability of algorithmic recommendations, and emergency response to technical failures. This systemic deficiency in digital ethics awareness may not only exacerbate the accumulation of risks in intelligent technology application but also, to some extent, inhibit teachers' initiative to explore the integration of data-intelligent technologies, forming a vicious cycle of "insufficient competence → avoidance of use → persistent backwardness." In summary, the deficiency in teachers' digital literacy and competence is concentrated in three dimensions—technical operation, pedagogical integration, and ethical cognition—resulting in the shallow-level application dilemma of data-intelligent technologies in rural education.

3.4 Fragmentation between Digital Resources and Indigenous Rural Ecosystems

Digital educational resources are of great significance for bridging regional educational gaps, enhancing teachers' professional competence, and supporting educational and pedagogical innovation (Wang, 2022). Rural education possesses unique regional cultures and educational needs, and this specificity requires that the development of digital resources must break free from standardized supply models. However, the current supply of digital educational resources exhibits deep-seated structural contradictions, the essence of which lies in the systematic disconnection between the standardized resource production model dominated by industrial thinking and the special needs of the rural educational ecosystem. First, this disconnection manifests as a serious misalignment between teaching content and the rural cognitive context. Mainstream digital textbooks and supporting resources generally adopt an urban-oriented design approach, extensively using urban life scenarios as teaching cases—from supermarket shopping and subway travel to visits to science and technology museums and urban parks. These contents, far removed from the daily life experiences of rural students, not only create barriers to understanding but also generate a sense of psychological alienation. Many rural teachers have to expend considerable effort in practical teaching on case replacement and contextual translation, and this additional teaching burden seriously affects instructional efficiency and quality.

Second, this disconnection also manifests as the persistent weakening of cultural transmission functions. The rural educational ecosystem has a dual nature: it must meet the standardized requirements of national basic education while also fulfilling the special mission of local cultural heritage. However, the current supply of digital resources exhibits a homogenizing tendency, making it difficult to balance these two demands. The digitization process of traditional cultural resources such as agricultural experience and folk crafts lags behind, mostly still relying on traditional methods such as oral transmission or physical display, failing to achieve innovative transformation through modern technology. At the same time, existing digital resources lack adaptability to the special scenarios of rural education and cannot effectively support composite teaching, small-scale schools, and other practical situations. This supply-demand contradiction makes it difficult for rural education either to meet standardization requirements or to fully fulfill its cultural transmission functions. The root cause lies in systemic deficiencies in resource development mechanisms, including insufficient research on rural cognitive characteristics, a lack of scientific standards for digitizing local culture, and an inadequate understanding of the composite nature of the rural educational ecosystem. This imbalance not only weakens the empowerment effect of data-intelligent technologies but may also further widen the urban-rural educational gap,

hindering the process of rural education revitalization.

Table 2. Critical Obstacles and Their Manifestations in Rural Practice

Obstacle	Core Manifestation	Supporting Evidence / Example
Technology-Need Mismatch	Urban-centric product design; rapid iteration vs. slow teacher adaptation	Rural teachers lag behind urban peers in adopting AI 2.0 tools; algorithmic content may erode local cultural identity
Cost-Resource Imbalance	High procurement/maintenance costs; regional funding disparities	99.9% of schools have broadband, yet maintenance budgets remain insufficient; hardware dominates spending while training lags
Digital Literacy Deficiency	Weak operational skills; poor pedagogical integration; ethics gaps	Most rural teachers only use basic projection functions; advanced features like intelligent grading remain underutilized
Resource-Context Fragmentation	Urban-oriented content; cultural heritage functions weakened	Rural teachers spend extra time replacing urban cases with local examples; folk crafts lack digital preservation

4. Practical Pathways for Empowering Rural Education Revitalization via Data-Intelligent Technologies under the Leading Educational Power Strategy

Rural education revitalization is not only essential to rural revitalization in the digital age but also a crucial pathway to narrowing intergenerational educational gaps and safeguarding educational equity (Zeng & Ouyang, 2025). In light of the multiple critical obstacles identified above, there is an urgent need to explore systematic practical pathways for empowering rural education revitalization through data-intelligent technologies. Focusing on the mechanisms of deep integration between data-intelligent technologies and rural educational scenarios, and grounded in the characteristics of rural education, this section integrates technological logic with educational values to break through developmental bottlenecks through targeted measures. The aim is to open up greater space for empowering rural education revitalization and to contribute to the realization of the leading educational power goals.

4.1 Precise Adaptation: Resolving the Dilemma of Technology-Need Dislocation

Technology is essentially a unity of material factors and spiritual factors, including skills, concepts, knowledge, theories, methods, and strategies (Lu, 2023). To achieve precise adaptation between data-intelligent technologies and rural educational scenarios, it is necessary to construct a systematic collaborative mechanism encompassing technology R&D, deployment strategies, and ethical governance. First, a demand-responsive technology R&D system should be established. This system must break through the path dependence of traditional technology supply, conduct in-depth needs analysis through interdisciplinary collaborative mechanisms, systematically deconstruct the particularities of teaching organization, cultural contexts, and resource environments in rural educational scenarios, and build a multidimensional demand-mapping model. Professional technical forces should be engaged to develop an architecture with dynamic adaptive capabilities, focusing on rigid constraints such as weak infrastructure to develop highly stable intelligent teaching systems that can maintain core functional stability under complex physical and social conditions. This approach corrects the cognitive bias of urban-rural dualism at the source of technology design, achieving an essential alignment between technological logic and educational values.

Second, the key lies in constructing differentiated technology deployment strategies. Based on the objective reality of unbalanced rural education development, it is necessary to establish tiered and categorized technology adaptation pathways, providing stepwise solutions for educational actors at different stages of development. Full-lifecycle technology management optimization should be implemented to extend the service life of key equipment, and regional technology resource collaboration platforms should be constructed. Through intensive allocation and sharing mechanisms, the structural pressure caused by differences in technology iteration rates can be alleviated, reserving space for flexible upgrades while ensuring the sustainability of basic services, thereby

forming a virtuous cycle of co-evolution between technology application and the educational ecosystem. Finally, an ethical collaborative governance framework should be established. Value-sensitive design paradigms should be embedded at the technological architecture level, employing cutting-edge computational models to enhance cultural inclusiveness and establishing content governance mechanisms adapted to regional characteristics. At the institutional construction level, a multi-stakeholder co-governance model should be established, strengthening the participation of grassroots educational actors in technology decision-making, improving data sovereignty protection and security systems, and achieving a dynamic balance between technological innovation and ethical safeguards through permission tiering and localized processing. This creates a protective mechanism against the erosion of indigenous cultural values by technological rationality. Therefore, through demand-anchoring mechanisms to eliminate supply deviations, flexible iteration strategies to bridge development gaps, and ethical collaborative frameworks to safeguard cultural subjectivity, These three elements together constitute a systematic solution to break the deep-seated dislocation between technology and context, laying the adaptive foundation for data-intelligent empowerment of rural revitalization.

4.2 Balanced Investment: Mitigating the Pitfalls of Cost-Resource Imbalance

Constructing a sustainable resource investment and allocation mechanism is key to overcoming cost constraints. In response to the structural contradictions between financial investment and resource allocation, there is an urgent need to establish a comprehensive governance system featuring multi-stakeholder collaboration and multi-dimensional safeguards, advancing synergistically from three aspects: investment structure optimization, regional allocation innovation, and operation and maintenance guarantee improvement. First, the benchmark of investment structure should be restructured, establishing a collaborative hardware-software resource allocation mechanism. Financial departments need to set up special funds, prioritizing soft investments such as curriculum development and teacher training through separate budgeting, and establish a technology procurement benefit evaluation system that incorporates equipment utilization rates and teacher competence matching into assessment indicators, thereby forcing precise alignment between hardware procurement and local needs. At the same time, public-private partnership models should be explored, guiding enterprises to reduce the initial investment burden through service leasing, performance sharing, and other means, forming a diversified investment landscape led by the government with social participation.

Second, regional allocation models should be innovated through the implementation of precision compensation strategies. A tiered certification system for rural schools' technology needs should be established, prioritizing resource allocation based on dimensions such as infrastructure levels and student-teacher ratios, with tilt-based allocation for under-resourced schools. A county-level technology resource flow network should be constructed, establishing shared service centers 依托 central schools, and promoting cross-school resource circulation through equipment rotation systems and teacher assignment mechanisms. Provincial-level fiscal transfer payments should be strengthened with a technology empowerment orientation, establishing special subsidies for remote areas and achieving dynamic matching between funds and needs through digital management platforms, effectively addressing resource allocation imbalances. Finally, sustainable guarantee systems should be improved, establishing a full-cycle operation and maintenance support system. Technology operation and maintenance funding should be clearly incorporated into county-level fiscal basic expenditure accounts, ensuring it does not fall below a guaranteed proportion of the annual education budget. An intelligent cloud-based health management platform for technology equipment should be established, integrating functions such as remote diagnosis, fault early warning, and performance monitoring, significantly reducing on-site maintenance costs. Standardized technology service procurement specifications should be formulated, strictly constraining hidden fees and mandatory upgrade clauses in enterprise service agreements. County-level joint maintenance collaboration mechanisms should be explored, establishing cross-school technology alliances and reducing marginal costs through scaled operation and maintenance and shared professional talent. Simultaneously, urban-rural education community development should be deepened, Leveraging 5G networks and digital platforms to expand new resource-sharing models such as prestigious school online classrooms and dual-teacher collaborative instruction. In summary, through deep-level reform of resource allocation methods, data-intelligent technologies can truly become a lever for promoting educational equity rather than a chasm that exacerbates division, laying a more solid resource guarantee foundation for rural education revitalization in the context of educational modernization.

4.3 Literacy Enhancement: Bridging the Gaps in Digital Literacy and Competence

Developing teachers' digital literacy aims to enable them to meet the challenges of the digital era and, more fundamentally, to bridge the digital divide and promote educational equity (Kong & Wang, 2023). In response to the structural shortage of digital literacy among rural teachers, there is an urgent need to construct a systematic, tiered capacity development system. First, a hierarchical mechanism for foundational competence cultivation should be established. A tiered curriculum system of "foundational literacy → integrated application → innovative practice" should be designed. The foundational level focuses on essential skills such as intelligent tool operation and equipment maintenance, developing a modular curriculum repository 依托 the National Smart Education Platform to support teachers' fragmented self-directed learning. The application level reinforces advanced competences such as intelligent grading and learning analytics through immersive training including workshops and on-site practice. The innovation level encourages participation in educational AI R&D projects. Simultaneously, teacher education systems should be reformed, establishing "Artificial Intelligence and Educational Practice" as a core compulsory course for teacher education majors with significantly increased practical hours. In-service training should establish a blended learning system to address the technology generation gap.

Second, pathways for pedagogical integration practice should be innovated. Interdisciplinary teams composed of university experts, technology enterprises, and teaching researchers should be assembled to develop a case repository of technology integration for typical subject teaching scenarios. A "school-based - regional" two-level learning community should be established: at the school-based level, demonstration lesson observation and collaborative lesson preparation should be carried out; at the regional level, virtual teaching and research sections should be constructed 依托 educational cloud platforms to facilitate cross-school case study and the accumulation of technology integration methodologies. Focus should be placed on breaking through deep application scenarios such as personalized learning support and intelligent assessment, guiding teachers to move beyond the stage of lesson plan digitization and master the core competence of reconstructing instructional processes through technology, through means such as dual-teacher collaborative instruction and immersive training. Finally, a technology ethics safeguard system should be constructed. Data privacy protection, algorithmic fairness assessment, and emergency response procedures should be incorporated into mandatory modules of teacher development, and localized ethics training courses should be developed. A school-level technology application ethics review mechanism should be established, with committees composed of teacher representatives, parents, and technology experts conducting risk assessment and compliance review of new technology solutions. The functions of county-level teacher digital capacity development centers should be improved, integrating intelligent lesson preparation systems and competence profiling tools to achieve precise resource delivery. Teacher evaluation reform should be deepened, incorporating technology application competence and integration innovation effectiveness into core criteria for professional title evaluation, forming a development cycle of "practice → reflection → certification." Through the three-dimensional approach of foundational capacity building, integration innovation empowerment, and ethical mechanism safeguarding, sustainable talent support is provided for the digital transformation of rural education.

4.4 Resource Development: Addressing the Disconnection between Digital Resources and Local Contexts

Rural education should preserve and transmit rural culture, bearing the responsibility and obligation for rural construction and talent introduction (Lu & Zhang, 2023). In response to the systematic disconnection between digital resources and the rural educational ecosystem, there is an urgent need to establish a multidimensional, three-dimensional new paradigm for resource development grounded in the dual nature of rural education, one that meets both the standardization requirements of national basic education and the special needs of local cultural heritage. First, a systematic research mechanism for local cognitive characteristics should be established. Interdisciplinary teams of educators, anthropologists, and rural teachers should be organized to conduct joint research through long-term fieldwork and classroom observation, deeply analyzing the cognitive characteristics and learning needs of rural students. Priority should be given to developing alternative teaching case repositories with local adaptability, transforming abstract disciplinary concepts into life experiences familiar to rural students. Meanwhile, AR/VR and other technological means should be employed to transform authentic elements from the rural environment into visualized teaching materials, creating an immersive learning experience where "the surrounding environment becomes a learning resource." This cognitive translation must not only address current teaching obstacles but also build a bridge for rural students connecting local cognition with modern knowledge.

Second, a complete development system of "collection → translation → curricularization" should be established.

Collaborative efforts with cultural scholars and intangible cultural heritage inheritors should be organized to digitally transform core cultural elements such as agricultural calendars and traditional crafts. A cultural gene database should be established through technologies such as 3D modeling, and interactive digital textbooks should be developed—for example, transforming weaving techniques into geometry curricula—achieving the organic integration of cultural heritage and subject teaching. At the same time, open collaborative platforms should be constructed to encourage teachers and students to participate in localized resource innovation. To maximize resource utilization, continuous optimization of resource allocation is essential (Chen, 2019). Finally, full consideration must be given to the particularities of rural education. For typical scenarios such as composite teaching and small-class instruction, flexible and reconfigurable modular digital resources should be developed. A distributed network combining county-level resource centers and school-level resource nodes should be established to achieve regional sharing and precise delivery of quality resources. At the same time, intelligent resource recommendation systems should be developed to provide personalized resource matching solutions based on dimensions such as teachers' teaching styles and students' cognitive characteristics. Through multi-stakeholder collaboration among "government, enterprises, schools, and community organizations," a new resource system that both meets national standards and takes root in local contexts should be constructed. The key to resolving the disconnect between digital resources and local ecosystems lies in constructing a synergistic development mechanism of cognitive adaptation, cultural heritage, and scenario integration. Through systematic resource development strategies, both educational quality and cultural roots are safeguarded, enabling digital resources to truly become a bridge connecting modern education and local culture, providing lasting momentum for rural education revitalization.

Future research could further investigate the long-term effectiveness of data-intelligent interventions across diverse rural contexts through longitudinal and comparative studies, with particular attention to the intersection of technological innovation and educational equity. Additionally, the ethical implications of algorithmic decision-making in rural education, such as data privacy and cultural algorithmic bias, remain underexplored and warrant critical examination in future empirical work. Bridging these research gaps will be essential for ensuring that the digital transformation of rural education is both effective and socially just.

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