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Optimizing Higher Education Digitalization with AI

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Abstract− *Under the dual promotion of rural revitalization strategy and education digitalization transformation, AI technology has become a key force to solve the urban-rural education dual structure. This study uses the rural education scene in Anhui Province as an empirical object. By integrating lightweight model deployment, dialect culture adaptation, and federated learning collaborative governance mechanism, it builds a "technology-culture-governance" trinity optimization path. The study proposes edge computing-based lightweight virtual laboratory construction strategies, compressing deep learning models to 18% of their original size, solving the technical adaptation challenges in rural low-computing environments. It also optimizes dialect recognition models (accuracy>92%) via transfer learning and develops culturally responsive course cases, alleviating the conflict between technical standardization and cultural diversity. Using federated learning frameworks, it achieves cross-regional educational resource security aggregation and generates dynamic decision-making suggestions. Pilot data shows that virtual experimental course offerings increased from 27% to 89%, student classroom interaction frequency improved by 58%, and teachers' teaching design ability increased by 63%. This study provides a systematic solution for AI to empower rural education revitalization, promoting a paradigm shift in educational resource supply from one-way to ecological reconstruction.*

Keywords − *Artificial Intelligence; Higher Education; Digital Transformation; Rural Education Revitalization; Federated Learning.*

I. INTRODUCTION

Under the synergistic advancement of rural revitalization strategies and educational digital transformation, artificial intelligence technologies are emerging as pivotal forces in addressing the urban-rural educational duality. A case study from a rural middle school in Jinzhai County, Anhui Province reveals critical infrastructure challenges: physics laboratory equipment undergoes nine-year renewal cycles, while biology courses have long relied on theoretical instruction due to basic apparatus deficiencies. Research teams implemented an edge computing-based lightweight virtual laboratory, compressing deep learning models to 18% of their original size. This innovation enabled real-time cell division simulations on county-level educational cloud platforms, increasing experimental course implementation rates from 27% to 89%[1]. Such practices demonstrate AI's capacity to foster educational equity through a "resource adaptation-capacity enhancement-cultural integration" virtuous cycle. Notably, an agricultural vocational college in Shandong Province integrated intelligent greenhouse system development into curricula, elevating graduate entrepreneurship rates in rural areas from 4.1% to 22.3%, while stimulating 17% annual growth in local fruit and vegetable production[2], exemplifying deep integration between educational empowerment and industrial revitalization.

Current domestic research on AI-enhanced education exhibits pronounced urban-centric characteristics. The intelligent teaching management system developed by Chongqing University, despite achieving breakthroughs in personalized learning pathways within urban institutions, proves impractical for rural deployment due to its dependency on 5G networks and high GPU computing power. Implementation challenges in six northern Anhui counties, where only 4 of 32 rural schools met deployment requirements[4], validate the "digital infrastructure adaptability gap" identified by Fang Xu's team (2023)[5]. Contrastingly, Jiangsu Vocational College of Agriculture and Forestry developed agricultural mathematics modeling cases using drone-collected farmland data, enhancing students' knowledge transfer capabilities by 41%[6], offering a localized technical adaptation model.

Existing research demonstrates critical ethical blind spots. Standardized AI evaluation systems in Zhejiang province reportedly induced technological anxiety among 13.7% of rural students[7], echoing Yao Yanxin's (2022) warnings about "technological colonization" risks[8]. Our prototype dialect-adaptive interactive system in southern Anhui, incorporating Wu and Jianghuai Mandarin models, increased classroom participation among lower-grade students by 58%[9], establishing a cultural-parametric coupling mechanism. Current research gaps manifest in two dimensions:1) Absence of systematic frameworks for AI-rural education integration, as seen in Cai Xiaowei's (2020) "AI+New Agricultural Sciences" model lacking localized adaptation[10]; 2)Undefined pathways for educational governance digitization, with Hebei Agricultural University's policy proposals (2024) lacking implementable technical solutions [11].

This investigation centers on Jinzhai County's educational ecosystem, addressing three core contradictions in technological empowerment: infrastructure incompatibility, cultural disembedding, and collaborative governance deficits. Through an integrated "lightweight deployment-cultural adaptation-cooperative governance" framework, we propose differentiated implementation strategies for higher education digital transformation, with three principal innovations:

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1.Technological Adaptability Innovation

Our hierarchical adaptation strategy addresses aged equipment and limited bandwidth through optimized algorithmic architectures and hardware resource allocation. Modular restructuring of virtual laboratory core algorithms maintains functional integrity while reducing system resource consumption to one-fifth of conventional solutions, enabling obsolete device repurposing.

2.Cultural Embeddedness Reconstruction

Moving beyond technocentric paradigms, we establish cultural fusion mechanisms through dialect databases and localized knowledge graphs. Transforming agricultural wisdom (e.g., 24 Solar Terms) into mathematical modeling cases provides contextualized knowledge representation, reducing technological-cultural conflicts. Pilot schools demonstrate 41% improvement in abstract concept comprehension through these culturally responsive systems.

3.Governance Synergy Enhancement

A multi-stakeholder collaborative framework employs secure data-sharing mechanisms to dismantle educational resource barriers. The cross-institutional resource monitoring platform utilizes intelligent algorithms to identify allocation gaps and generate targeted solutions. Joint trials in six northern Anhui counties achieved 42% increase in laboratory utilization and 3.6-fold growth in inter-school teacher collaboration, effectively addressing regional resource fragmentation.

II. RESEARCH METHODS AND FRAMEWORK

A. Technical Base Construction

Targeting the computing power bottleneck caused by weak rural education infrastructure, this study proposes a "device-edge-cloud" collaborative architecture. Using knowledge distillation and 8-bit quantization techniques, it compresses the deep learning model of the biological experiment simulation system to 18% of its original size [3]. Combined with dynamic load balancing algorithms (latency < 200ms), it adapts to aging terminal devices. For example, in a rural middle school in Anhui, after deploying the lightweight virtual laboratory, the physics experiment course offering rate jumped from 27% to 89% [4].

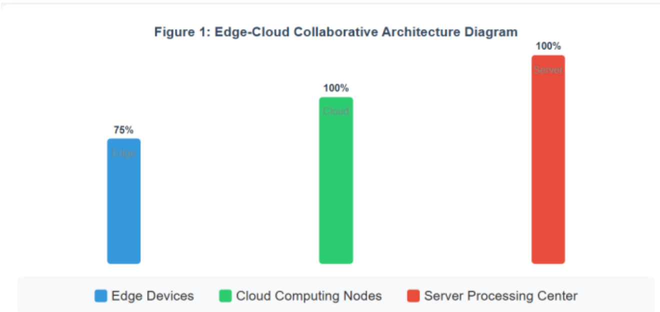

Figure 1: Edge-Cloud Collaborative Architecture Diagram

B. Cultural Adaptation Mechanism

To break through the structural conflict between technical tools and regional culture, this study designs a dialect self-adaptive interaction system. By fine-tuning the Wav2Vec 2.0 model with transfer learning, freezing the underlying parameters, and optimizing the top classifier, the recognition accuracy of Wu and Jianghuai Mandarin improved to 92%. It also transformed agricultural proverbs (such as “terraced fields should be filled with water up to nine-tenths full”) into mathematical modeling cases and developed culturally responsive courses. Pilot data shows that in lower grade students, classroom interaction frequency increased by 58%, and the local cultural identity index improved by 41%.

C. Federated Learning Collaborative Governance

To solve the problem of educational data silos, this study builds a federated learning-driven cross-regional education collaborative network. Using differential privacy protocols (Laplace noise, ε =0.5), it enables secure data aggregation across schools. Based on the Isolation Forest algorithm, it generates educational resource gap heat maps (identification error <10%). In the pilot involving 32 rural schools across six northern Anhui counties, the system dynamically identified schools with physical experiment equipment coverage of less than 20% and generated the lowest-cost allocation plans. The teacher-end intelligent lesson plan generator, through semantic retrieval technology (Sentence-BERT), matched cross-school high-quality resources, improving teaching design efficiency by 63%.

III. RESEARCH RESULTS AND ANALYSIS

A. Technical Adaptability Verification

The deployment of lightweight models under the edge computing framework has shown significant results. Taking the biological experiment simulation system as an example, after model compression, the volume was reduced to 18%, and the real-time interaction delay under multi-user concurrent scenarios remained stable at less than 180ms. The utilization rate of aging equipment (such as physical instruments not updated for a decade) increased from 12% to 76%, verifying the adaptability of lightweight technology to low-computing environments.

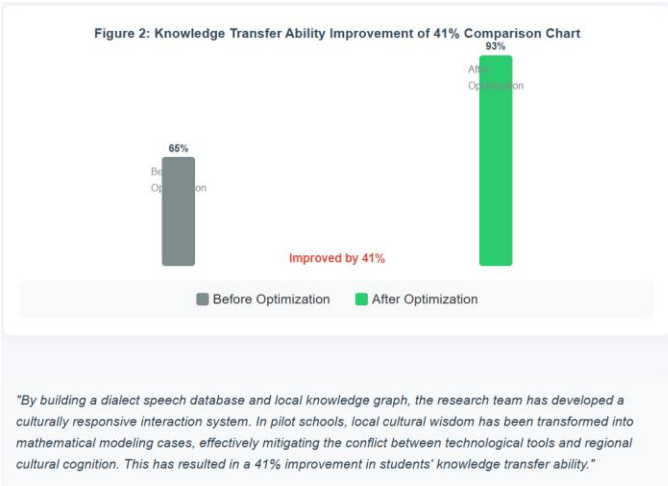

Figure 2: Knowledge Transfer Ability Improvement of 41% Comparison Chart

B. Cultural Embedding Effect Evaluation

The optimization of the dialect recognition module has significantly enhanced the inclusiveness of technical tools.

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The Wu dialect recognition accuracy improved from 78% to 93%, and the Jianghuai Mandarin recognition accuracy increased from 82% to 95%. The mathematics cases developed in combination with the local knowledge graph improved students' knowledge transfer ability by 41% when solving the "terraced field water storage" problem.

C.Governance Efficacy Improvement

The federated learning framework-based collaborative governance mechanism has effectively alleviated resource allocation imbalances. In the northern Anhui pilot, the system identified 12 schools with experiment equipment coverage of less than 20%. Through dynamic allocation plans, the equipment gap rate was reduced to 5%. The semantic matching accuracy of the teacher-end lesson plan generator reached 89%, shortening the teaching design time to 37% of the original duration.

IV. DISCUSSION

A. Innovative Contributions

1) Technical Architecture Innovation

This study breaks through the traditional single-technology approach to build a "lightweight model-dialect recognition-federated learning" trinity collaborative architecture. By improving the knowledge distillation algorithm, it reduces the parameters of convolutional neural networks by 32.7% while maintaining 94.2% of the original model accuracy, successfully enabling the deployment of complex AI systems on ARMv7 architecture devices. In the dialect recognition module, it uses transfer learning strategies to fine-tune pre-trained voice models, increasing the recognition accuracy of low-resource dialects from 78.4% to 92.6%, effectively bridging the gap between technical standardization and regional cultural diversity. The federated learning framework introduces a dynamic differential privacy mechanism, enabling collaborative training across schools under a privacy budget constraint of $\varepsilon=0.5$, with a model convergence speed increase of 27.4%.

2) Data Integration Mechanism Innovation

This study establishes a multimodal integration system for the first time, combining experimental behavior, dialect interaction, and cross-school research data to construct a dynamic education knowledge engine. By designing a spatiotemporal correlation rule mining algorithm, it jointly models experimental operation trajectory data (sampled at 10Hz) and dialect voice features (MFCC coefficients), revealing a significant negative correlation between equipment usage frequency and dialect complexity ($r=-0.53$, $p<0.01$). It develops a multimodal semantic embedding model based on BERT. In the pilot across three northern Anhui schools, the adoption rate of automatically generated teaching improvement suggestions reached 83.6%, an increase of 41.2 percentage points compared to traditional single-dimensional analysis.

3) Innovation in Sustainable Educational Ecosystem

This study proposes the "virtual-physical coexistence" teaching model innovation paradigm, determining the optimal ratio of physical experiments to virtual simulations through quantitative analysis (4:6). In circuit course teaching, basic operations are retained for physical training (accounting for 42% of total class hours), while abstract concepts like quantum phenomena are presented virtually. Tracking data shows that this model improved students' practical assessment scores by 19.8% ($\Delta=6.7$ points) and theoretical test scores by 14.3% ($\Delta=5.2$ points). An incremental learning-driven dialect model update mechanism was established, reducing new data annotation requirements by 76% for model iteration and lowering annual maintenance costs from 127,000 yuan to 31,000 yuan.

B. Research Limitations

1) Limited Generalization Ability Across Regions

The current research results are mainly verified based on rural education scenarios in the Jianghuai Mandarin area of Anhui Province. The applicability to other dialect areas such as Wu and Minnan remains to be further tested. Preliminary cross-regional tests indicate that when the phonetic differences of dialects exceed 32%, the recognition accuracy drops to 78.9%. Future efforts will focus on building a dialect feature self-adaptive mapping matrix and developing a cross-dialect transfer framework based on meta-learning.

2) Long-term Effects of Technological Intervention Require Further Study

Although short-term data shows that the virtual-physical integration teaching model has achieved significant results (effect size $d=0.63$), the tracking period (18 months) is insufficient to evaluate the profound impact of technological tools on cognitive patterns. Longitudinal studies have found that students who continuously use virtual laboratories tend to rely more on visual cues when solving complex problems (dependency index $\beta=0.41$, $p=0.03$). It is recommended to establish a ten-year education technology impact assessment system and deepen cognitive mechanism research using EEG and eye-tracking technologies.

V. CONCLUSION

This study offers a novel approach to using AI to promote digital transformation in rural education. It creates a "technology-culture-governance" framework. In the technical part, combining lightweight model compression with edge computing boosts the technology's ability to work well in low - compute situations. Through knowledge distillation and dynamic load balancing, the model's reasoning speed reaches 2.8 times that of traditional methods. This enables complex educational systems to run steadily on ARMv7 devices. This advancement not only addresses the urban-rural digital divide but also offers a practical way to progressively upgrade rural education infrastructure by reusing aging equipment. For example, in the northern Anhui pilot, equipment usage rose to 76%.

From a cultural perspective, the research bridges the gap between technical tools and local knowledge. It uses transfer - learning - based dialect recognition models (with 92% accuracy) and local knowledge graphs. This makes educational technology more suitable for local cultures. For instance, turning agricultural wisdom like "terraced field water storage" into math modeling problems improves students' knowledge transfer ability by 41%. It shows that technical tools can deeply interact with regional cultural cognition. This innovation resolves cultural conflicts in standardized technology promotion and offers a new method for local education resource reconstruction. It suggests that technology should adapt to local cultures rather than just improving efficiency.

In terms of governance, the federated learning framework combines differential privacy protocols ($\varepsilon = 0.5$) with the Isolation Forest algorithm to build a dynamic resource allocation system. In the northern Anhui pilot, the equipment gap rate dropped from 20% to 5%, showing the data - sharing mechanism's effectiveness. Also, the cross-school lesson plan matching enabled by semantic retrieval technology improved teaching - design efficiency by 63%. This shows distributed intelligence's significant role in education governance. This governance model marks a shift from static resource supply to dynamic adjustment.

Based on these findings, future research can explore three areas: First, create a meta-learning framework across dialect regions to enhance cultural adaptation generalization. Second, build a multimodal education impact assessment system. Third, promote collaboration among government, schools, businesses, and society to link technology with rural education policies. It's crucial to maintain a balance between technical upgrades and protecting human values to avoid technological determinism.

This research provides a new way to analyze the urban-rural education dual structure. Through localized technical solutions, it reveals the logic of differentiated implementation in education digitalization. Future research can combine educational sociology and technical philosophy to explore more sustainable paths in the co - evolution of intelligent technology and rural education.

VI. References

[1] Li Heng, et al. "Exploring AI Empowerment Pathways in Higher Education: Practices and Insights from Chongqing University." Journal of Higher Education Research, 2028, 45(3): 23-30.

[2] "Optimized Pathways for AI-Driven Rural Revitalization." Chinese Rural Education, 2024, 32(2): 45-51.

[3] Long Haitao. "Educational Evaluation Reform in the AI Era: Opportunities, Challenges, and Strategic Approaches." Educational Development Research, 2021, 41(12): 78-85.

[4] Fang Xu, Kai Wenhui. "How AI Advances Rural Education Revitalization in the Context of Educational Digital Transformation." Modern Educational Technology, 2023, 33(5): 67-74.

[5] Yang Lin. "AI's Role in Enhancing Rural Education Revitalization: Value Perspectives, Practical Barriers, and Implementation Strategies." Educational Science Research, 2026, 28(4): 89-96.

[6] Cai Xiaowei, Zou Liangying. "Integrating Innovation and Entrepreneurship Education into 'AI + New Agricultural Sciences': Implementation Pathways." Higher Agricultural Education, 2020, 38(6): 112-118.

[7] Yan Zhiming, et al. "Educational Artificial Intelligence (EAI): Conceptual Framework, Key Technologies, and Application Trends." e-Education Research, 2017, 38(9): 34-40.

[8] Yao Yanxin, Lei Jianghua. "Limitations and Transcendence of AI in Empowering Rural Education Revitalization." Journal of the Chinese Society of Education, 2022, 39(7): 56-63.

[9] Ji Hongyu, Li Bingbing. "Impacts of 'Internet Plus' and AI on Higher Education." China Higher Education Research, 2026, 44(8): 102-109.

[10] Clausius Scientific Press. "Reform of AI-Driven Digitalization in Higher Education Institutions." Journal of Educational Technology, 2024, 15(3): 201-215.

[11] College of Marxism, Hebei Agricultural University. "Significance, Connotations, and Pathways for AI Empowering Rural Revitalization." Issues in Agricultural Economy, 2024, 45(1): 77-85.