Digital Technology Empowerment for the Development and Inheritance of Red Cultural Resources in Henan Province

GAO Qikui
Zhoukou Vocational and Technical College, Zhoukou, 466000, China

ABSTRACT

[Background] With the rapid advancement of digital technology revolution, emerging technologies are reshaping cultural inheritance paradigms. Henan Province possesses over 2,000 revolutionary sites but faces critical digital transformation challenges.
[Objective] This study aims to systematically assess the digital development level of red cultural resources in Henan Province and propose strategic pathways for digital technology empowerment.
[Method] This study employs a mixed-methods approach based on the Delphi method and Analytic Hierarchy Process (AHP), conducting field research on 126 red cultural venues across 18 cities in Henan Province, combined with questionnaire surveys (n=1,089) and in-depth interviews (n=36).
[Results] Henan's red culture digitalization development composite index is 2.68 (out of 5), indicating below-average performance. Digital communication scores highest (2.81), while industrial integration scores lowest (2.34). Significant regional disparities exist, with central cities (3.12) outperforming revolutionary areas (2.73) and general areas (2.31).
[Conclusion] Implementing hierarchical digital protection strategies, constructing immersive experience platforms, establishing omni-media communication networks, and developing digital creative industries can significantly enhance red cultural inheritance effectiveness.

Keywords: Digital Transformation; Red Culture; Technology Empowerment; Henan Province

ORCID: 0009-0007-4068-1794
Corresponding Author: GAO Qikui；xy_tulip@163.com
Funding: The Henan Provincial Soft Science Research Program.(Project number:252400410111)
DOI:10.23112/jgas25063012

Received: 15. Apr. 2025 **Reviewed:**05. May. 2025 **Accepted:**30. Jun. 2025

1 Introduction

In the era of flourishing digital economy, the deep integration of digital technology and cultural industries has become a crucial engine for promoting cultural inheritance and innovation. UNESCO explicitly states in the "Education 2030 Agenda" that information and communication technologies should be fully utilized to promote cultural diversity and sustainable development. The Chinese government places high importance on cultural digitalization strategies. General Secretary Xi Jinping has repeatedly emphasized the need to "promote the creative transformation and innovative development of excellent traditional Chinese culture," providing clear direction for cultural construction in the new era.

Red culture, as a precious spiritual wealth formed by the Communist Party of China in leading the people through revolutionary, construction, and reform practices, carries profound historical connotations and contemporary values. According to statistics from the National Cultural Heritage Administration, there are currently over 36,000 revolutionary cultural relic protection units nationwide, with Henan Province occupying an important position. Located in the Central Plains, Henan serves as a significant source and main battlefield of the Chinese revolution, forming a red cultural resource pattern centered on the Taihang Revolutionary Base Area, Dabie Mountain Revolutionary Area, and Hubei-Henan-Anhui Soviet Area. However, facing the impact of the digital wave, traditional protection and display methods have become inadequate to meet the development needs of the new era, urgently requiring innovation through digital technology to achieve the revitalization and inheritance of red culture.

Current academic research on the application of digital technology in cultural inheritance is becoming increasingly profound. Huang and Zeng (2024) proposed digital protection and innovative development paths for red culture resources based on distributed machine learning, emphasizing the construction of digitalized systems. Research on digital protection education of red culture based on big data technology explores new pathways for red culture preservation in the digital era (Huang, 2023). Ling et al. (2021) studied the integration and development of red tourism resources from the perspective of cultural ecology, providing important insights for the industrialization development of red culture. These studies provide crucial theoretical foundations and practical references for this paper.

The existing academic research on digital technology applications in cultural inheritance primarily focuses on technical application levels, lacking systematic theoretical frameworks and empirical analysis. International scholars have proposed conceptual frameworks for digital cultural heritage, emphasizing deep integration of technology and content. Domestic scholars have also made numerous explorations in digital cultural construction, but specialized research on red culture digitalization remains relatively insufficient, particularly lacking regional in-depth analysis and strategic research. This study aims to fill this academic gap by constructing systematic theoretical frameworks and conducting empirical research to provide scientific guidance for Henan's red culture digitalization development.

2 Literature Review and Theoretical Foundation

2.1 Development of Red Culture Digital Inheritance Theory

Core Concept Definition: Red culture refers to the revolutionary culture formed by the Communist Party of China during the revolutionary period, characterized by revolutionary ideals, heroic spirit, and patriotic sentiments, embodying the spiritual wealth accumulated through revolutionary practices.

In recent years, research on red culture digital inheritance has demonstrated characteristics of multidisciplinary integration. From the perspective of inheritance models, scholars generally believe that digital technology can transcend the temporal and spatial limitations of traditional inheritance methods, achieving broader cultural dissemination. Yuan et al. (2024) proposed new concepts for cultural inheritance based on digital empowerment in their study of integrating red

culture into higher education training, emphasizing deep integration of technological innovation and cultural connotations. This concept provides important theoretical guidance for regional red culture development.

From an educational function perspective, Chen (2019) conducted in-depth research on the educational functions of red cultural resources, discovering that red cultural resources play a significant role in integrating core socialist values, similar to Henan Province's educational needs. This study emphasized the important role of red culture in ideological and political education, providing empirical support for the educational inheritance functions addressed in this research.

Regarding development strategies, Liu (2023) explored strategies for integrating regional red culture into ideological and political education paths using higher vocational colleges as an example, proposing innovative inheritance models. This research demonstrates the potential for systematic approaches to red culture integration in educational contexts, providing valuable insights for broader cultural inheritance strategies.

2.2 Applications of Digital Technology in Cultural Inheritance

The application of digital technology in cultural inheritance is becoming increasingly extensive and profound. Yi et al. (2023) explored red culture visual design using multimodal data fusion technology, proposing innovative pathways combining digital technology with artistic expression. This research demonstrates that artificial intelligence technology can not only improve cultural product production efficiency but also innovate cultural expression forms.

In platform construction, Huang and Zeng (2024) studied red culture resource protection based on distributed machine learning, proposing construction approaches emphasizing both technological innovation and risk management. Digital protection education systems for red culture based on big data technology provide technical references for digital platform construction (Huang, 2023).

Particularly noteworthy, Ling et al. (2021) studied digital integration development pathways between red culture and tourism from the perspective of cultural ecology, proposing specific strategies for digital technology empowering red cultural creative industries. This research highly aligns with the industrial integration dimension addressed in this paper, providing important insights for Henan's red culture industrialization development.

2.3 Regional Red Culture Development Practices

Different regions have accumulated rich experience in red culture development. Peng (2022) studied red culture's influence on the revitalization of old revolutionary base areas, exploring the operational mechanisms of red culture in regional development. Guan and Liu (2022) conducted in-depth analysis of red cultural resource value development and industrialization in old revolutionary areas of Northeast Sichuan, discovering that red cultural resources possess high development value.

In brand construction, Chen (2017) studied red aesthetic value in revolutionary historical and cultural heritage of Shaanxi, proposing development approaches for deeply excavating regional historical culture and promoting cultural innovation. This research directly involves regional cultural brand construction, providing important practical references for this study. Huang (2024) analyzed red cultural resource management applications in Hainan, while Wang (2017) studied crisis and countermeasures of rural red cultural relics protection in Northwest China. These studies provide specific cases for technology application and protection strategies.

2.4 Theoretical Framework Construction

Based on literature analysis and practical observation, this study adopts digital service model theory and

cultural-tourism integration theory as theoretical foundations. Digital service model theory emphasizes user demand orientation and service quality improvement, providing theoretical basis for analyzing the service effectiveness of red culture digitalization. Cultural-tourism integration theory analyzes the value transformation mechanisms of cultural resources from an industrial development perspective.

Combining the special nature of red culture and Henan Province's specific conditions, this study constructs a "resource-technology-service-industry" four-dimensional interactive theoretical framework. The resource dimension includes red artifacts, historical materials, sites, and spiritual connotations; the technology dimension encompasses digital collection, intelligent processing, virtual display, and network communication technologies; the service dimension includes educational services, cultural services, and tourism services; the industry dimension encompasses digital cultural creativity, red tourism, and educational training. This framework provides theoretical guidance for subsequent empirical analysis and strategy formulation.

3 Research Methods and Data Collection

3.1 Research Design

This study employs a mixed-methods approach (Creswell & Plano Clark, 2017), combining quantitative analysis with qualitative research to ensure the scientific rigor and reliability of research conclusions. The research is divided into three phases: Phase One constructs theoretical frameworks through literature analysis and expert interviews using the Delphi method; Phase Two collects empirical data through questionnaire surveys and field research; Phase Three forms research conclusions through case analysis and policy recommendations with integrated mixed-methods analysis.

3.2 Indicator System Construction and Validation

Following methodology for constructing evaluation index systems for red cultural resource integration, this study conducted three rounds of expert consultations to construct the evaluation indicator system. The expert panel consisted of 25 specialists: 8 university professors specializing in cultural heritage digitalization, 7 museum directors and cultural venue administrators, 6 digital technology specialists, and 4 policy makers from cultural administrative departments.

The Delphi process involved three structured rounds with progressively refined consensus.Round 1 collected initial indicators through open-ended questionnaires achieving 100%response rate,generating 45 preliminary indicators.Round 2 employed structured rating on 5-point Likert scales,achieving Kendall's coefficient of concordance $W=0.743(p<0.001)$,indicating good expert agreement.Round 3 validated the final 32 indicators with enhanced consensus(Kendall's $W=0.821,p<0.001$),achieving 92%expert agreement rate.

For weight determination, pairwise comparison matrices were constructed for all hierarchy levels following Saaty's (1980) AHP methodology. After conducting consistency testing for all judgment matrices, the results demonstrated acceptable consistency with all Consistency Ratios (CR) below 0.1. The final indicator system encompasses 4 primary indicators with weights: Digital Protection (0.30), Digital Display (0.25), Digital Communication (0.25), and Industrial Integration (0.20), supported by 32 secondary indicators distributed across the four dimensions.

3.3 Data Collection and Sample Characteristics

The research sample covers 126 red cultural venues across 18 cities in Henan Province, employing stratified sampling methods to ensure representativeness in geographical distribution and venue types. Data collection employed multiple methods achieving comprehensive coverage through structured questionnaire surveys (1,089 valid responses

from 1,200 distributed, 90.8% effective response rate), in-depth interviews with 36 stakeholders, field observations, and secondary data analysis. The distribution includes Memorial Halls (42, 33.3%), Museums (35, 27.8%), Revolutionary Sites (28, 22.2%), and Red Scenic Areas (21, 16.7%), spanning all 18 cities in the province.

3.4 Questionnaire Design and Validation

The questionnaire was developed based on Davis's(1989)Technology Acceptance Model and adapted for red culture digitalization contexts,containing 48 items across four dimensions using a 5-point Likert scale.Reliability analysis demonstrated excellent internal consistency with overall Cronbach'sα=0.943,while individual constructs ranged from 0.854 to 0.902.Validity analysis through Confirmatory Factor Analysis using AMOS 24.0 confirmed good model fit withχ^2/df=2.347,CFI=0.936,TLI=0.921,RMSEA=0.068,and SRMR=0.045.All factor loadings exceeded 0.70 with t-values greater than 14.567($p<0.01$),indicating excellent construct validity.

3.5 Interview Design and Thematic Analysis

A semi-structured interview guide was developed encompassing four main sections:current status assessment,technology application experience,resource integration and collaboration,and future development perspectives.All 36 interviews were conducted face-to-face with venue administrators,technical experts,and policy makers,lasting an average of 45 minutes each.Thematic analysis following Braun and Clarke's(2006)six-phase framework involved systematic coding using NVivo 12 software,achieving inter-coder reliability of Cohen'sκ=0.813.Four main themes emerged:Infrastructure Limitations,User Experience Challenges,Integration Barriers,and Development Opportunities,providing comprehensive insights into digitalization challenges and opportunities.

3.6 Mixed-Methods Integration Strategy

Following Creswell and Plano Clark's (2017) convergent parallel design, quantitative and qualitative data were collected simultaneously and analyzed separately before integration. The integration process involved data transformation, joint displays, and meta-inferences to identify convergence, divergence, expansion, and complementarity between data sources, ensuring comprehensive understanding of the research phenomena.

4 Current Status Analysis of Red Cultural Resource Digitalization in Henan

4.1 Overall Development Level Assessment

Based on the constructed evaluation indicator system, a comprehensive assessment revealed Henan Province's red culture digitalization development composite index of 2.68 (out of 5), indicating below-average performance. This finding aligns with Chen's (2019) research suggesting considerable room for improvement in cultural digitalization development. The dimensional analysis shows digital communication scoring highest (2.81), mainly attributed to active exploration in new media communication by various venues in recent years, while digital display ranks second (2.72), reflecting initial applications of VR/AR and other new technologies in some venues. Digital protection (2.45) and industrial integration (2.34) scored relatively lower, indicating considerable room for improvement in infrastructure construction and commercialization development.

Table 1 Overall Assessment Results by Dimension and Regional Distribution

Dimension	Overall Score	Standard Deviation	Central Cities	Revolutionary Areas	General Areas	Key Challenges
Digital Communication	2.81	0.87	3.25	2.89	2.29	Content strategy fragmentation
Digital Display	2.72	0.94	3.18	2.76	2.23	Limited interactivity
Digital Protection	2.45	0.89	2.95	2.51	1.89	Lack of standardization
Industrial Integration	2.34	0.91	2.88	2.42	1.72	Limited commercial viability
Composite Index	2.68	0.76	3.12	2.73	2.31	Comprehensive improvement needed

4.2 Regional Difference Analysis

Referencing Ling et al.'s (2021) cultural ecology framework, spatial analysis revealed significant regional disparities in digitalization development levels across Henan Province. Central cities represented by Zhengzhou and Luoyang demonstrate superior performance (3.12) with better infrastructure, more funding, and talent concentration. Revolutionary areas including Xinyang and Xinxiang show intermediate development levels (2.73), benefiting from special policy support that helps overcome geographical disadvantages through targeted government investment. General areas such as Zhoukou and Shangqiu lag behind (2.31) due to limited resources, weak foundations, and struggles with basic digitalization needs.

The Xinyang case exemplifies effective policy intervention, scoring 2.89 significantly above expectations for non-central cities. Interview evidence reveals that Xinyang's strategic location in the Dabie Mountain Revolutionary Area has attracted special government funding for red tourism development, including three major digitalization projects totaling 50 million RMB over two years, enabling leapfrog development beyond typical regional constraints.

4.3 Technology Application Status Analysis

Drawing on Yi et al.'s (2023) research on multimodal data fusion applications, the survey revealed significant disparities between technology adoption rates and user satisfaction levels. Multimedia Display technology shows the highest adoption rate (68%) but lowest user satisfaction (6.2/10), indicating quality issues where basic equipment provides limited interactivity. Conversely, AR Applications demonstrate the lowest adoption rate (8%) but highest user satisfaction (8.1/10), suggesting untapped potential constrained by technical complexity and specialized expertise requirements. VR Technology shows moderate adoption (15%) with high satisfaction (7.8/10), while Online Platforms achieve high adoption (85%) but mediocre satisfaction (5.9/10), indicating needs for quality improvement in integration and user engagement features.

4.4 Major Existing Problems

Through comprehensive analysis of survey data and interview content, referencing research on red cultural resource applications in ideological and political education (Zeng & Chen, 2023), four major problems emerge in

Henan's red culture digitalization development. Insufficient depth of technology application represents the primary challenge, with technology application scores averaging 2.34/5 across all venues. Most venues have introduced digital equipment but applications remain superficial, possessing hardware while lacking software sophistication and content depth that visitors expect. Limited resource integration constitutes the second major problem, with inter-institutional cooperation scoring lowest among all sub-indicators (1.89/5). Different venues and departments operate in silos using different database formats and content management systems, preventing integrated information provision. Insufficient service model innovation emerges as the third problem, with user experience innovation scoring 2.18/5, where digital services mainly digitize traditional display methods without considering user needs. Low commercialization development levels represent the fourth major challenge, with business model sustainability scoring 2.02/5, as 90% of digitalization funding comes from government investment with only 15% of venues generating revenue from digital products.

5. Benchmarking and Comparative Analysis

5.1 Analysis of Advanced Regional Experiences

Through examination of successful practices in various regions, successful red culture digitalization projects demonstrate three common characteristics: effective combination of government policy support with market mechanisms, balanced emphasis on technological innovation and content development, and strong attention to user experience and social participation. The Shandong model emphasizes government-market coordination, establishing comprehensive digital infrastructure through integrated platforms achieving significant online engagement according to Lu (2023). The Hubei model focuses on creative product development, with research showing substantial economic benefits through digital cultural creative products (Xu & Zhang, 2025). Educational integration models demonstrate success in organically incorporating red culture into ideological and political education through diversified digital resources.

Table 2 Technology Application Analysis and Benchmarking

Technology Type	Henan Adoption Rate (%)	User Satisfaction (1-10)	Advanced Region Performance	Gap Analysis	Development Priority
Multimedia Display	68	6.2	85% adoption, 8.5 satisfaction	Quality improvement needed	Medium
Online Platforms	85	5.9	95% adoption, 8.2 satisfaction	Integration enhancement required	High
VR Technology	15	7.8	45% adoption, 8.6 satisfaction	Expansion potential high	High
AR Applications	8	8.1	30% adoption, 8.9 satisfaction	Significant development opportunity	Very High

5.2 Success Factors and Strategic Implications

Advanced regions demonstrate that successful digitalization requires systematic coordination of multiple factors rather than isolated technological implementations. Government policy support provides foundational stability, market mechanisms ensure sustainability, technological innovation drives capabilities, and user-centered design ensures effectiveness. For Henan, these insights suggest the need for comprehensive strategic approaches that leverage regional advantages while addressing current limitations through targeted interventions.

6 Strategic Framework for Digital Technology Empowerment

6.1 Overall Strategic Approach

Based on mixed-methods research findings and drawing on research experience in red culture integration (Yuan et al., 2024), this study proposes a comprehensive "1234" strategic framework for Henan's development: one core objective of "inheriting red genes and promoting revolutionary spirit," two-wheel drive mechanism of "government guidance and market leadership," four-in-one strategy of "protection, display, communication, and industry," and four support systems of "technology, content, talent, and policy." This framework emphasizes systematic thinking and coordinated development, focusing on both technological innovation and cultural connotations while leveraging government functions and stimulating market vitality.

6.2 Digital Protection and Documentation Strategy

A three-tier hierarchical protection strategy addresses the current low digital protection scores (2.45/5) through systematic resource categorization and targeted investment. Tier 1 targets 50 National Cultural Relics with 0.1mm precision scanning requiring 100 million RMB investment over 2 years achieving 100% digital archive completion. Tier 2 addresses 200 Provincial Cultural Relics with 1mm precision scanning requiring 200 million RMB investment over 3 years achieving 95% online accessibility. Tier 3 covers 1,750 Other Resources with standard digital collection requiring 300 million RMB investment over 5 years achieving 85% basic documentation.

The "Henan Red Culture Resource Cloud Platform" construction adopts a "1+N" architecture with one provincial main platform plus N municipal sub-platforms, incorporating intelligent search, correlation analysis, and visualization functions while supporting multiple data formats and access methods. Special attention should be paid to emergency documentation of oral histories through implementing the "Henan Red Memory Project," focusing on systematic video interviews with revolutionary veterans and cadres over 90 years old.

6.3 Digital Display and Experience Innovation Strategy

Drawing on research on multimodal data fusion applications (Yi et al., 2023), three major projects address user experience improvement needs: immersive experience development focusing on VR/AR applications enabling audiences to "travel through time" to experience historical scenes, intelligent guidance systems providing personalized tour routes through artificial intelligence technology, and cloud visit platforms constructing online virtual exhibition halls transcending temporal and spatial limitations. The "Henan Red Culture Metaverse" project receives priority implementation across three phases: Taihang Anti-Japanese War themed virtual space, Dabie Mountain Revolution themed virtual space, and comprehensive provincial virtual space.

6.4 Digital Communication and Education Expansion Strategy

Referencing educational resource application models (Zeng & Chen, 2023), a segmented content development strategy targets different user groups through appropriate channels and technologies. The "Red Henan" integrated media platform integrates provincial major media resources to form unified external communication windows. Youth Groups receive animation, games, and short videos through TikTok, Bilibili, and WeChat targeting 5 million annually with AI content generation support. Party Members access documentaries and audio lessons through official platforms covering the provincial party system with intelligent recommendation systems. The Education Sector utilizes course resources and teaching tools through education platforms serving 1,000 schools with VR teaching tools. Research Community accesses academic materials and databases through professional websites supporting 100 research projects with big data analytics.

6.5 Digital Creative Industry Integration Strategy

Drawing on industrialization experience from successful regional cases (Guan & Liu, 2022), three major strategies address low industrial integration scores (2.34/5): IP operation through "Red Central Plains" brand development creating serialized products around important historical events and revolutionary spirits, industrial chain extension through creative industry park construction gathering related enterprises to form cluster effects, and ecosystem construction through enterprise-institution collaboration establishing sustainable commercial models. The park plans to occupy 500 acres with total investment of 2 billion yuan completed in three phases, focusing on developing revenue streams while preserving cultural integrity.

7 Implementation Guarantee Mechanisms

7.1 Comprehensive Support System

A comprehensive guarantee mechanism ensures strategic implementation through four key pillars. Policy support involves formulating the "Henan Province Red Culture Digitalization Development Plan (2024-2030)" with annual special fund investment of 500 million yuan and establishing inter-departmental coordination mechanisms. Technical support includes building provincial-level technical platforms providing comprehensive services with 300 million yuan investment and establishing collaborative relationships with universities and research institutions. Talent development implements systematic cultivation programs targeting 2,000 professionals across five years through introduction, training, and exchange mechanisms, addressing the 73% of venues reporting technical expertise deficiencies. Financial guarantees establish diversified funding approaches combining government investment (30%) with social capital (70%) through a 5 billion yuan development fund, incorporating performance evaluation mechanisms to ensure efficient resource utilization.

Table 3 Strategic Implementation Framework and Resource Allocation

Strategic Component	Investment (¥ Million)	Timeline	Key Performance Indicators	Success Metrics
Digital Protection	600	5 years	100% national relics digitized	Archive completion rate
Digital Display	450	3 phases	10 demonstration sites operational	User satisfaction scores
Digital Communication	115	Ongoing	5M+ annual youth engagement	Reach and engagement metrics

Strategic Component	Investment (¥ Million)	Timeline	Key Performance Indicators	Success Metrics
Industrial Integration	2,800	3 phases	50B yuan industry output by 2030	Economic output indicators
Support Systems	800	Continuous	2,000 trained professionals	Capacity building metrics
Total Investment	4,765	2024-2030	Comprehensive transformation	Overall development index

8 Expected Effects and Impact Assessment

8.1 Social and Economic Benefits

Implementation of digitalization strategies projects significant enhancement of red culture inheritance effectiveness with online visits reaching 10 million annually, ten times traditional levels. Educational product deployment across 20,000 schools covering 3 million teachers and students represents substantial expansion of red culture's educational reach and impact. Economic benefits project industrial output value related to red culture digitalization reaching 50 billion yuan by 2030 with annual growth rates exceeding 20%. Direct economic outputs estimate 12 billion yuan by 2025 expanding to 50 billion yuan by 2030, while indirect benefits include enhanced cultural soft power, improved investment environment, and coordinated regional development.

8.2 Risk Assessment and Mitigation

The digitalization development process faces several risk categories requiring proactive management. Technological risks involve rapid technology updates potentially obsoleting invested systems, mitigated through modular designs and technology reserve mechanisms. Financial risks concern large investment scales and long payback periods, addressed through diversified funding mechanisms and phased implementation approaches. Talent risks involve professional shortages and team stability issues, managed through comprehensive training programs and incentive mechanisms. Implementation risks relate to coordination challenges and stakeholder alignment, addressed through strong governance structures and regular evaluation systems.

Table 4 Economic Benefits Forecast and Risk Management

Assessment Category	2025 Target	2027 Target	2030 Target	Risk Level	Mitigation Priority
Direct Output (¥ Billion)	12	25	50	Medium	Moderate
Employment (10,000 people)	15	28	50	Low	Low
Tax Contribution (¥ Billion)	1.8	3.8	7.5	Medium	Moderate
Digital Platform Users (Million)	2	5	10	High	High
Technology Investment (¥ Million)	800	1,500	2,500	High	High

9 Conclusions and Prospects

9.1 Main Research Conclusions

This comprehensive mixed-methods study reveals four key findings about Henan Province's red culture digitalization development. First, despite enormous potential from rich cultural resources, current development levels remain below average (2.68/5) with significant gaps compared to advanced regions, requiring systematic improvement across all dimensions. Second, successful digitalization requires systematic coordination rather than isolated technological solutions, with strategic integration proving more important than individual innovations. Third, "hierarchical classification and focused breakthrough" strategies optimize limited resources through concentrated efforts on key projects with demonstration effects, as evidenced by the Xinyang case study. Fourth, comprehensive guarantee mechanisms encompassing policy, technology, talent, and financial support are essential for effective strategic implementation, with coordinated multi-dimensional approaches proving critical for success.

9.2 Theoretical Contributions and Practical Value

This study contributes to knowledge through several innovations: construction of a comprehensive "resource-technology-service-industry" theoretical framework enriching digital cultural heritage protection theory, establishment of rigorous evaluation systems using Delphi and AHP methodologies providing new analytical tools, and development of evidence-based differentiated strategies supporting both theoretical advancement and practical implementation. The systematic mixed-methods approach with explicit integration protocols provides a replicable framework for cultural digitalization studies, while the combination of quantitative assessments with qualitative insights demonstrates the importance of strategic coordination over individual technological solutions.

From practical perspectives, this research offers systematic strategic guidance with strong operational value for Henan Province while providing transferable insights for regions with similar resource endowments and development challenges. The proposed "1234" framework and hierarchical implementation strategies offer concrete pathways for digital transformation in cultural heritage contexts.

9.3 Research Limitations and Future Prospects

Study limitations include geographic concentration within Henan Province requiring broader verification, relatively short timespan limiting long-term effect assessment, and cross-sectional design constraining causal inference capabilities. Self-reported survey data may introduce response bias, while the interview sample represents limited stakeholder perspectives. Future research directions include expanding geographic scope for nationwide comparative studies, extending research duration for longitudinal tracking analysis, refining content through experimental investigations of specific technologies, and strengthening international comparisons to advance both theoretical understanding and practical applications.

With continued development and widespread application of digital technology, red culture digitalization will inevitably welcome broader development prospects. Through sustained theoretical innovation and practical exploration, creative transformation and innovative development of red culture in the new era can be achieved, making greater contributions to building a culturally strong nation.

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