Article

Design of a Digital Twin Campus Model for Red Ideological and Political Education Based on 5G,VR, Blockchain, and Rule of Law Principles

Zipeng Li [1,*]

[1] College of Humanities and Law (School of Discipline Inspection and Supervision), Chengdu University of Technology, Chengdu, 610059, China
* Correspondence: Zipeng Li, College of Humanities and Law (School of Discipline Inspection and Supervision), Chengdu University of Technology, Chengdu, 610059, China

Abstract: With the rapid advancement of digital technology, digital education has become an important pathway for expanding educational development and cultivating new advantages in the field of education. Against this technological backdrop, and amid the continuous innovation of values-oriented and civic education in universities, emerging technologies such as 5G, virtual reality (VR), and blockchain provide new possibilities for enhancing cultural education and reforming traditional teaching models. Conventional instructional approaches in this field face practical challenges, including limited interactive scenarios, fragmented educational resources, and insufficient integration between technology and pedagogy. This paper proposes the construction of a digital twin campus platform centered on cultural education, supported by 5G, VR, and blockchain technologies and guided by relevant legal and regulatory principles. Based on a three-tier architecture consisting of a data layer, a platform layer, and an application layer, the system aims to achieve immersive presentations of historical and cultural scenarios, integrated management of educational content, and collaborative sharing of interdisciplinary resources. The data layer is responsible for standardized data collection, storage, and encryption to ensure information security and compliance. The platform layer integrates digital modeling, identity authentication, and smart contract mechanisms to enhance operational transparency and reliability. The application layer provides interactive learning modules, virtual simulations, and participatory activities to improve students' engagement and experiential learning outcomes. At the same time, embedding legal expertise into the design and operation of the platform helps prevent potential risks such as data privacy concerns, intellectual property disputes, and cybersecurity vulnerabilities. Through the coordinated integration of technology, culture, and legal norms, the proposed platform seeks to strengthen students' cultural understanding and active participation, promote balanced allocation of educational resources, and explore an innovative educational model that integrates culture, technology, and the rule of law. Such an approach contributes to the digital transformation of higher education and supports the sustainable and equitable development of educational practices in the digital era.

Keywords: Digital Twin Campus Model, 5G, Rule of Law Principles, Red Ideological and Political Education

Received: 20 December 2025
Revised: 06 February 2026
Accepted: 20 February 2026
Published: 25 February 2026

1. Introduction

In the contemporary context, values-oriented and civic education in higher education institutions undertakes the essential task of cultivating students' moral awareness, social responsibility, and comprehensive competencies. However, it continues to face practical challenges, including relatively uniform instructional formats, limited student engagement, fragmented educational resources, and insufficient responsiveness to

students' individualized learning preferences and emotional expectations. Traditional classroom-based approaches often rely heavily on textual explanation and one-way knowledge transmission, which may constrain experiential learning and interactive participation. As a result, there is an increasing need to explore more flexible, technology-enhanced educational models that can respond to the evolving characteristics of university students in the digital age.

At the same time, emerging technologies are reshaping the landscape of higher education. The low latency and high bandwidth of 5G technology enable real-time data transmission and seamless connectivity; the immersive and interactive features of virtual reality (VR) technology create multi-sensory learning environments; and the traceability and tamper-resistant characteristics of blockchain technology enhance data credibility and transparent resource management. The integration of these technologies provides new possibilities for reforming humanities-oriented education and expanding innovative pedagogical pathways.

Against this background, this study centers on cultural education content that plays an important role in values-oriented instruction and proposes the construction of a collaborative digital twin campus platform guided by the principle of the rule of law. By employing a digital twin framework, the platform seeks to simulate and extend real campus environments into virtual space, enabling interactive cultural learning scenarios, diversified resource integration, and cross-disciplinary collaboration. Through a structured architecture that supports data integration, platform coordination, and application-level interaction, the model aims to overcome the temporal, spatial, and methodological limitations of traditional instructional modes.

Furthermore, the incorporation of legal and regulatory considerations into platform design ensures compliance in areas such as data protection, intellectual property management, and ethical governance of technology use. Through the dual support of technological empowerment and legal frameworks, the proposed model aspires to realize scenario-based cultural education, collaborative sharing of high-quality educational resources, and dynamic evaluation of learning outcomes. In doing so, it provides a systematic approach to enhancing student participation, strengthening cultural understanding, and promoting the sustainable and high-quality development of higher education in the digital era.

2. Literature Review

2.1. The Digital Transformation of Values-Oriented Education

Traditional values-oriented and civic education exhibits notable limitations in terms of conceptual clarity, implementation coherence, and evaluation mechanisms. Existing studies have pointed out that although an overall framework has been formed in which moral and civic elements are integrated across curricula, practical challenges remain, including ambiguous core concepts, fragmented implementation pathways, and insufficiently systematic assessment standards [1]. In addition, rigid instructional formats and predominantly one-way knowledge transmission models often fail to respond effectively to the learning preferences and participatory expectations of contemporary students.

Technological advancements provide an important pathway for reform in humanities and civic education. Recent research suggests that digital and intelligent technologies not only expand access to educational resources but also facilitate a shift in teaching models from unilateral knowledge delivery to interactive and inquiry-based learning [2]. Immersive tools such as virtual reality (VR), online collaborative platforms, and intelligent analytics systems enable multi-dimensional engagement, helping address issues of limited interaction and one-dimensional evaluation in traditional classrooms. These developments provide significant support for the digital transformation of values-oriented education and contribute to the modernization of pedagogical approaches.

2.2. Key Technologies and Educational Integration

Emerging technologies such as VR, blockchain, and digital twin systems demonstrate distinctive value in contextualized and experiential teaching activities. Studies have shown that VR technology, by leveraging multidimensional perception and simulated environments, can construct highly realistic learning scenarios that transform abstract theoretical knowledge into more tangible and intuitive experiences [3]. Empirical analyses in applied teaching contexts further indicate that immersive technologies can enhance student engagement, deepen conceptual understanding, and improve knowledge retention [4].

Digital twin technology has also begun to show potential in educational settings. By mapping and synchronizing physical and virtual campus elements, digital twins can create interactive learning environments and support real-time data analysis of learning behaviors [5]. Through digital preservation and virtual reconstruction of historical and cultural resources, educational content can transcend temporal and spatial limitations, broadening access and strengthening learners' sense of cultural understanding and participation [6]. The integration of digital repositories, virtual exhibition spaces, and intelligent feedback systems provides a comprehensive technical foundation for innovative educational practices.

2.3. Rule of Law Principles and Digital Twin Governance

The principle of the rule of law plays a crucial role in guiding and regulating digital transformation in education. While digital technologies enhance efficiency and expand educational possibilities, they also introduce potential risks, including data security vulnerabilities, algorithmic bias, privacy concerns, and governance challenges. Research emphasizes that legal and regulatory frameworks are necessary to define the principle of minimum data necessity, clarify rights and obligations, and establish accountability mechanisms to ensure that technological applications remain aligned with educational objectives [7].

From the perspective of cultural digitalization, scholars have observed that digital transformation processes often involve both decentralizing and centralizing tendencies in resource allocation and governance structures [8]. In this context, the rule of law functions as a balancing mechanism that coordinates diverse stakeholder interests, protects individual cultural rights, and sets clear compliance boundaries for technological applications such as digital twins. Through institutional arrangements-such as tiered data protection systems, standardized data governance protocols, and transparent oversight mechanisms-legal frameworks can mitigate risks associated with technological misuse and ensure the sustainable and responsible development of digitally enhanced cultural and civic education.

3. Building a Digital Twin Campus for Red Culture Under the Rule of Law Principle

3.1. Framework

The overall framework design is shown in Figure 1.

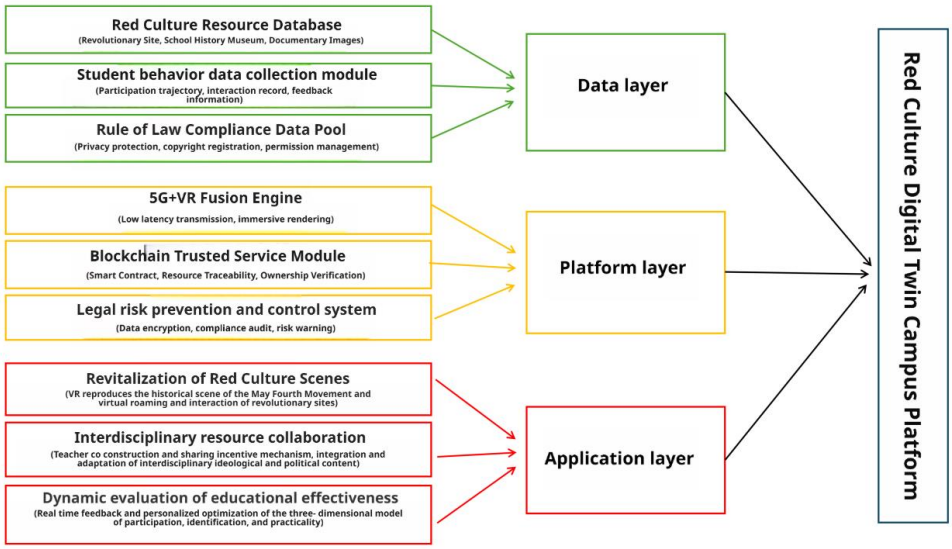

Figure 1. Construction Model of the Digital Twin Campus for Red Culture.

3.2. Core Modules and Functions

The proposed research framework consists of three core components: the data layer, the platform layer, and the application layer. The data layer integrates a cultural education resource database, a student learning behavior data collection module, and a legal compliance data repository, thereby establishing a structured foundation for both data governance and regulatory oversight. Through standardized data classification, encryption protocols, and access control mechanisms, this layer ensures data integrity, privacy protection, and alignment with applicable legal and ethical requirements. In addition, metadata tagging and interoperable standards are introduced to facilitate cross-platform compatibility and long-term resource sustainability.

The platform layer provides the technical infrastructure necessary for system operation. It integrates a 5G-VR fusion engine, a blockchain-based trusted service module, and a legal risk prevention subsystem. The 5G-VR integration supports high-speed transmission and real-time rendering of immersive learning environments, ensuring stable and low-latency user experiences. The blockchain module enhances data transparency, traceability, and tamper resistance in resource sharing and participation records. Meanwhile, the legal risk prevention subsystem incorporates compliance review procedures, automated alerts for abnormal data usage, and predefined governance protocols, enabling end-to-end risk pre-control and strengthening operational reliability.

The application layer functions as the practical implementation dimension of the platform and promotes the digital and scenario-based upgrading of cultural and civic education through three interconnected approaches.

First, it facilitates the revitalization of historical and cultural learning scenarios. By leveraging the low-latency capabilities of 5G technology and the immersive characteristics of VR, the system reconstructs representative historical scenes within a digital twin environment, creating interactive experiential spaces. For example, through a virtual simulation of significant historical events such as the May Fourth Movement, students can engage in role-based interaction within historically contextualized settings. This experiential approach transforms abstract historical narratives into perceptible learning experiences, thereby enhancing comprehension and critical reflection. Standardized digital resources generated through this process can subsequently be shared across institutions, improving resource efficiency and promoting balanced educational access.

Second, the platform supports collaborative cross-disciplinary resource integration. By utilizing blockchain-based smart contracts to design transparent co-creation and incentive mechanisms for educators, the model encourages interdisciplinary collaboration.

It enables the integration of cultural education content with legal studies, literature, history, and other fields, thereby customizing instructional modules for students from different academic backgrounds. For instance, students majoring in law may examine the historical development of legal institutions within broader social transformations, while literature students may explore cultural narratives through immersive digital archives. This approach reduces disciplinary isolation and enhances student engagement through contextualized learning.

Third, the system implements a dynamic educational impact assessment mechanism. A multidimensional evaluation framework is established to measure engagement, cognitive identification, and practical application. Blockchain technology ensures the secure and traceable recording of participation trajectories, protecting data authenticity while respecting privacy boundaries. Analytical tools correlate interactive performance in virtual scenarios, collaborative project participation, and involvement in campus cultural activities to generate comprehensive feedback reports. Rather than relying solely on summative examinations, the model emphasizes formative assessment and behavioral analytics, thereby supporting continuous improvement in teaching strategies and learning outcomes. Through this integrated structure, the platform seeks to combine technological innovation, pedagogical refinement, and legal governance into a coherent and sustainable educational model.

4. Implementation Path and Expected Outcomes

4.1. Implementation Phases

The rollout of the platform adopts a phased and progressive implementation strategy to ensure technical feasibility, legal compliance, and pedagogical effectiveness. In the initial phase, priority is given to the integration of cultural education resources and the construction of immersive digital scenarios. Educational materials are systematically curated from three dimensions: regional cultural heritage, institutional historical traditions, and representative historical events with broad educational significance. During the processes of scenario digitization and interactive design, strict adherence is maintained to the legal principle of "minimum necessary" data collection, ensuring that only essential user data are processed and that privacy protection and data security standards are embedded from the outset.

Following the completion of scenario construction, the second phase focuses on platform development and pilot implementation. Core system functions-including immersive interaction modules, blockchain-based participation recording, and data governance tools-are developed and tested in controlled environments. Pilot programs are launched in selected universities with relatively mature digital infrastructure and rich cultural education resources to ensure stable technical conditions and meaningful application contexts. During this stage, continuous monitoring mechanisms are established to collect operational data, user feedback, and learning performance indicators.

In the third phase, systematic feedback analysis and model optimization are conducted. Data generated during pilot operations are analyzed to evaluate platform usability, student engagement levels, interdisciplinary integration effectiveness, and compliance performance. Particular attention is paid to identifying potential tensions between technological applications and legal or ethical requirements, such as data retention boundaries, algorithmic transparency, and informed consent procedures. Based on these assessments, functional modules, governance mechanisms, and user interfaces are refined to enhance stability, scalability, and regulatory alignment. The objective of this phase is to develop a replicable and adaptable educational model that integrates technological innovation, pedagogical design, and legal governance into a coherent system.

In the final phase, outcomes are summarized and disseminated, and corresponding governance recommendations are formulated. Promotion strategies are tailored to different types of higher education institutions and regional development contexts to ensure contextual adaptability. Enhanced cybersecurity protocols, tiered data protection mechanisms, and standardized operational guidelines are emphasized during large-scale deployment. At the same time, policy suggestions are proposed to relevant educational and digital governance authorities to improve regulatory coordination, clarify compliance standards, and establish long-term oversight frameworks for technology-enhanced cultural and civic education platforms. Through this structured and iterative implementation pathway, the platform aims to achieve sustainable expansion while maintaining legal integrity, technological reliability, and educational quality.

4.2. Expected Outcomes

Through the construction of core functional modules and the implementation of a structured four-step strategy, the research anticipates several comprehensive outcomes.

First, by utilizing immersive VR-based learning environments, the platform is expected to enhance students' experiential engagement with historical and cultural content. Rather than relying solely on textual explanation, immersive simulations enable learners to interact with reconstructed historical contexts in a multi-sensory manner. This approach strengthens cognitive understanding, deepens emotional resonance with cultural narratives, and promotes reflective learning, thereby improving the overall effectiveness of values-oriented education.

Second, the establishment of a transparent co-creation and incentive mechanism is designed to reduce disciplinary fragmentation and promote interdisciplinary collaboration. Through shared digital repositories and blockchain-supported contribution records, educators from different academic fields can collaboratively develop and refine educational content. This mechanism facilitates the efficient circulation and coordinated utilization of cross-disciplinary resources, encouraging the integration of cultural education with law, literature, history, and social sciences, and ultimately enhancing instructional coherence and innovation.

Third, the research aims to construct a quantifiable and dynamically adjustable evaluation framework for educational effectiveness. By adopting a multidimensional assessment model that integrates engagement metrics, cognitive development indicators, and behavioral participation data, the platform addresses the limitations of traditional single-indicator evaluation approaches. Continuous data analysis supports formative assessment, enabling educators to refine instructional strategies in real time and improve the precision and adaptability of teaching interventions.

Fourth, the project seeks to develop an integrated educational model that combines technological infrastructure, cultural content, and legal governance mechanisms into a coherent system. This model is intended to demonstrate replicable value across diverse higher education contexts, offering a structured implementation pathway for the digital transformation of cultural and civic education. By aligning technological innovation with pedagogical objectives and compliance requirements, the framework aspires to support the sustainable and high-quality development of higher education in the digital era.

5. Discussion

This research proposes a scenario-based educational pathway for culturally oriented civic education, promoting a transition from predominantly one-way knowledge transmission to immersive and interactive learning. By reconstructing historical and cultural contexts within digital environments, the model enhances experiential engagement and strengthens the connection between learners and educational content. At the same time, it establishes a coordinated resource-sharing mechanism that mitigates fragmentation in existing educational materials and improves cross-institutional

collaboration. Through structured digital repositories and interoperable standards, the platform enhances the systematic integration and efficient circulation of high-quality resources.

In addition, the study develops a dynamic evaluation framework that integrates participation metrics, cognitive engagement indicators, and practical application capacity. This multidimensional assessment system moves beyond traditional single-factor evaluation models and supports evidence-based refinement of teaching strategies. By incorporating legal compliance mechanisms into technological design, the research also emphasizes data protection, transparent governance, and responsible innovation. The proposed framework demonstrates how cultural education, digital technology, and regulatory principles can be integrated into a coherent model for the digital transformation of higher education. Furthermore, the platform offers potential support for extending high-quality educational resources to under-resourced regions, thereby contributing to more balanced educational development while maintaining compliance with applicable legal standards and ethical norms.

6. Conclusions

In conclusion, the construction of a legally compliant digital twin campus platform for culturally oriented education provides a systematic solution to challenges such as rigid instructional scenarios and fragmented resource allocation in traditional teaching models. By integrating immersive technologies, collaborative governance mechanisms, and dynamic assessment tools, the model offers an innovative pathway for enhancing the effectiveness and sustainability of digital education in higher education institutions. It demonstrates the feasibility of aligning technological advancement with pedagogical objectives and regulatory requirements in a balanced and responsible manner.

Nevertheless, the research also acknowledges certain limitations. The reliance on advanced digital technologies entails relatively high development and operational costs, which may constrain large-scale implementation across institutions with limited technical infrastructure. Future research will focus on optimizing system architecture to reduce costs, improve scalability, and enhance accessibility. In addition, subsequent studies may explore broader application scenarios, including K-12 research-based learning environments and community-oriented cultural initiatives, thereby expanding the adaptability and long-term impact of digitally enhanced cultural education in diverse educational contexts.

Funding: This research was supported by the Undergraduate Innovation and Entrepreneurship Training Program (Project No.: S202510616061). The financial support provided essential resources for the design, implementation, and advancement of this study.

Acknowledgments: The successful completion of this thesis benefited greatly from the collaborative efforts of the project team and the supportive academic environment provided by the university. The authors sincerely appreciate the constructive guidance offered throughout the project design and manuscript preparation process. Gratitude is also extended to all institutions, mentors, peers, and individuals whose assistance and encouragement contributed to the completion of this research.

References

1. W. Liu, and C. He, "Curriculum-Based Ideological and Political Education: Research Focuses and Evolution," *International Education Studies*, vol. 15, no. 5, pp. 28-35, 2022.
2. A. A. Yakin, A. J. Obaid, M. Muthmainnah, and A. S. Ibrahim, "Social dynamics investigation of digital humanities user behavior practices in higher education through artificial intelligence," In *AIP Conference Proceedings*, September, 2024, p. 080004. doi: 10.1063/5.0234483
3. Y. Wang, Y. Zhang, and Y. Wang, "The Application of Virtual Reality (VR) Technology in Contextualized Learning in Higher Education and Its Impact on Students' Comprehension," *Curriculum and Teaching Methodology*, vol. 7, no. 3, pp. 67-77, 2024.
4. B. C. Arjun, and K. R. Sanjay, "Enhancing military training through VR applications," *International Scientific Journal of Engineering and Management*, vol. 3, no. 5, pp. 1-9, 2024.

5. S. Luo, "Construction of situational teaching mode in ideological and political classroom based on digital twin technology," *Computers and Electrical Engineering*, vol. 101, p. 108104, 2022. doi: 10.1016/j.compeleceng.2022.108104
6. E. Boamah, "Towards effective management and preservation of digital cultural heritage resources: an exploration of contextual factors in Ghana (Doctoral dissertation, Open Access Te Herenga Waka-Victoria University of Wellington)," 2014.
7. R. Vettriselvan, "Empowering Digital Education: The Future of Value-Based Learning in the Digital Era," In *Empowering Value Co-Creation in the Digital Era*, 2025, pp. 199-228.
8. R. Tao, "Innovative Application of Legal Methodology in Digital Protection of Cultural Heritage," *Mediterranean Archaeology and Archaeometry*, vol. 25, no. 3, 2025.