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Article

Intelligent Pathways for the Preservation of Traditional Chinese Music Culture and Optimization of the Education System in the Big Data Environment

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Abstract: With the development of digital technology, the inheritance of traditional Chinese music culture requires the integration of intelligent technology advantages with the characteristics of traditional Chinese music culture, updating the path of inheritance and development, and accelerating the transformation of traditional Chinese music culture education towards intelligence and professionalism. Digital technology enables the intelligentization of traditional Chinese music culture inheritance. In the field of education and teaching, regarding data security management, this paper proposes utilizing blockchain's hash functions and cross-chain technology to design a cross-chain-based copyright protection scheme for traditional Chinese music culture resources, and establish a blockchain-based digital copyright protection and transaction system for traditional Chinese music culture. Functional testing of the blockchain-based digital copyright protection and transaction system for traditional Chinese music culture is conducted to verify its effectiveness in promoting the inheritance and development of traditional Chinese music culture. Surveys of students' perceptions of the inheritance and development of traditional Chinese music culture in school educational activities have identified activities that students recognize as important for inheritance. Combining digital technology, it is proposed that the inheritance of traditional Chinese music culture can be conducted thematically based on educational activities that students enjoy, ensuring the high quality and professionalism of the inheritance of traditional Chinese music culture.

Keywords: blockchain cross-chain; hash function; copyright protection; traditional Chinese music culture

1. Introduction

The development of traditional Chinese music can be traced back to the time of the Yellow Emperor. Through the continuous integration and development of “Central Plains music,” “music from the four regions,” and “foreign music,” it has evolved into a traditional music system with distinctive Chinese characteristics [1-3]. This self-contained musical culture, with its unique, profound, elegant, and luminous style, resonates in the hearts of the Chinese people and echoes through the annals of history, leaving behind numerous outstanding musical works for humanity [4-6]. However, with the development of globalization, Western music theory has begun to erode China's music domain, and Chinese music creators have gradually aligned themselves with Western music composition. Traditional music has entered a developmental crisis and even begun to decline, signaling a challenging period for the development of Chinese traditional music [7-10]. In this context, leveraging big data to achieve the intelligent inheritance of traditional music culture and the optimization of educational systems is an inevitable path for the inheritance and development of Chinese traditional music culture [11-12].

In contemporary society, big data has become an indispensable resource in various fields, with its application scope becoming increasingly widespread [13-14]. In the field of traditional music cultural heritage protection and inheritance, the application of big data has also demonstrated enormous potential and advantages [15-16]. In terms of cultural heritage protection and inheritance, big data can play a role in many areas, including digital management of cultural heritage, cultural heritage research and

protection strategy formulation, and cultural heritage dissemination and display, thereby realizing the intelligent inheritance of traditional music culture [17-20]. At the same time, there are issues within the education system, such as the low proportion of traditional music culture and outdated teaching methods, which have led to a lack of understanding of traditional music culture among students [21-23]. It is necessary to leverage big data to optimize the integration of traditional music culture and technology, online and offline platforms, and personalized teaching, thereby laying an educational foundation for promoting the inheritance of traditional music culture [24-26].

Reference [27] analyzes the current state of traditional Chinese music in the context of big data, revealing that with the development of information and media technology, traditional music is gradually declining and facing a severe survival crisis. It emphasizes the importance of information technology in the inheritance of traditional music culture. Reference [28] introduces Guangfu traditional music and the challenges it faces in the context of diversified development. Based on the application of big data, it conducts research on Guangfu traditional music culture and proposes development suggestions for the existing issues in Guangfu traditional music culture. Literature [29] examines methods for optimizing the inheritance of ethnic music culture based on technologies such as deep learning (DL), analyzes the current status, background, and content of ethnic music culture inheritance, and proposes solutions integrating artificial intelligence technology. The results indicate that DL methods play an important role in the inheritance of ethnic music culture. Literature [30] examines innovative cultural dissemination pathways for local opera using data mining technology, proposes a data mining-based method for analyzing and identifying innovative cultural inheritance pathways for local opera, and conducts research from the perspectives of technical clustering and technical theme association. Literature [31] systematically introduces Chinese folk vocal music and the impact of Western cultural influences on it, and conducts research on Chinese folk vocal music from a big data perspective to understand its development trends. Literature [32] constructed a music dataset on the Manchu ethnic group in China, aiming to promote the application of artificial intelligence in cultural heritage and ethnic musicology, and revealed the application potential of this dataset in ethnic music classification and generation. Literature [33] utilized big data auxiliary technology to examine the importance of traditional music cultural inheritance, analyzed the challenges currently faced by traditional music education, and reflected on reforms in ethnic music education. Literature [34] emphasizes the importance of establishing a model for the protection and inheritance of traditional music and points out that this is necessary to adapt to the technological and cultural developments of the internet age.

This paper analyzes the components of Chinese traditional music culture and understands the inheritance and development of Chinese traditional music culture. It highlights the feasible paths for the inheritance of Chinese traditional music culture with the assistance of digital technology. A blockchain-based digital sharing model for traditional Chinese music culture is designed, with the establishment of blockchain platform objectives and the development of functional service modules for a traditional Chinese music culture inheritance system platform. Combining hash functions and blockchain cross-chain technology, a copyright protection scheme for traditional Chinese music cultural resources based on blockchain cross-chain technology is designed. A blockchain-based digital copyright protection and transaction system for traditional Chinese music culture is established, with functional testing conducted for digital resource copyright protection. The inheritance and development of traditional Chinese music culture in school educational activities are analyzed.

2. New inheritance of traditional Chinese music culture

2.1. Overview of Traditional Chinese Music Culture

Traditional Chinese music is currently divided into four major categories: folk songs, ethnic instrumental music, variety music, and opera music [35]. Traditional Chinese music culture has the following characteristics:

First, it is historical. The emergence and development of traditional Chinese music culture has accompanied the progress and development of history. Many traditional music genres were formed early on, and they were created during different historical periods and cultural contexts, exhibiting distinct characteristics of their respective eras and historical significance.

Second, synchrony. The development of a particular traditional music form may vary due to differences in local social structures, economic development, folk customs, and dialects. Even the same song, dance, or opera genre may exhibit different nuances when performed by different musicians in different regions.

Thirdly, there is continuity. The process of the emergence, development, evolution, and decline of music culture is always continuous across time. Music culture is a cultural phenomenon passed down through generations, and its continuity is a crucial condition for its survival and perpetuation. Certain

elements of traditional music culture exhibit relative stability during their transmission and development, and this relative stability is a key reason for their ability to be passed down uninterrupted.

Fourth is its educational nature. By continuously exploring the outstanding cultural elements within traditional Chinese music, one can grasp the underlying ideas and philosophy, providing education, guidance, and value shaping for both appreciators and practitioners of traditional music culture.

Fifth, inclusiveness. Chinese traditional music culture is inclusive and accommodating. Its enduring vitality stems from its consistent adherence to the principle of survival of the fittest, absorbing outstanding elements from foreign music cultures. The exchange between Chinese and foreign music cultures can be traced back to the Zhou Dynasty. During the Han Dynasty and the Sui and Tang Dynasties, Central Plains culture and Western Region culture were undergoing extensive exchange. During the Ming and Qing Dynasties, Chinese music culture and Western music culture continuously collided, absorbed, and fused with one another. Under different historical periods, political and economic conditions, and cultural backgrounds, these exchanges left deep historical imprints on traditional Chinese music culture.

2.2. The inheritance and development of traditional Chinese music culture

“In terms of the definition of traditional Chinese music, it refers to musical genres and works that originated on Chinese soil throughout history (including ancient and modern times) and have largely survived to the present day, as well as those introduced by foreign ethnic groups in ancient historical contexts and subsequently rooted and developed in China.”

Chinese traditional music has survived in folk culture through vocal and/or instrumental art forms, passed down orally from generation to generation, resulting in an vast repertoire of pieces. Among these, art forms primarily performed through vocal singing, such as widely circulated folk songs, opera, and music, are often created orally by individuals and gradually refined through collective refinement over centuries of transmission. Therefore, traditional Chinese music is a symbol of the wisdom of Chinese civilization, embodying a rich national spirit and representing the crystallization of intangible cultural heritage. The significance of preserving traditional Chinese music for the development of Chinese traditional culture is self-evident.

"Historically, the transmission of traditional Chinese music has primarily followed two pathways: natural transmission and institutional transmission. These two forms of oral transmission are still widely practiced in folk traditions today." Natural transmission includes family-based individual transmission and collective transmission through folk customs and activities. Family-based transmission refers to the subtle transmission of skills from elders to younger generations in a natural and unforced manner, regardless of time or place, ensuring the continuous transmission and promotion of traditional Chinese music culture. Such cases are numerous in the history of traditional Chinese music. Folk customs and activities passed down by various ethnic groups serve as important platforms for traditional musicians with diverse talents to showcase their skills, as well as prime opportunities for collective transmission of musical techniques among folk musicians. Traditional music performances provide the general public with opportunities to observe, learn, exchange, share, and promote traditional music culture. Institutional transmission refers to the management and dissemination of traditional music through official government-established music institutions across dynasties, which has had a significant impact on the transmission and development of traditional Chinese music.

With the development of the times, the channels for the transmission of traditional music have undergone significant changes: in most rural areas, due to the long-term migration of young and middle-aged adults for work, the naturally advantageous family-based environment and background that once supported traditional transmission no longer exist, and many folk festival activities have gradually decreased or even been forgotten.

Chinese traditional music culture is profound and extensive, representing a valuable intangible cultural heritage of humanity. It deserves protection, and inheritance is a crucial driving force for safeguarding traditional music culture. The principle of seeking development through inheritance and seeking change through development implies that the inheritance of traditional music culture should continuously explore innovative paths by integrating with emerging fields of the new era. This approach will better facilitate the development of traditional music culture, enabling Chinese traditional music culture to transcend national borders and reach the world.

2.3. Digital Technology Empowering the Preservation of Traditional Chinese Music Culture

2.3.1. Intelligent Path

(1) Interactive Experience: Innovative Applications of VR and AR Technology

Digital technologies such as virtual reality (VR) and augmented reality (AR) have opened up new avenues for the dissemination of traditional music. They have not only transformed the way music is produced and performed but also provided audiences with immersive experiences, thereby paving the way for new avenues of traditional music dissemination.

(2) Diverse Platforms: Multimedia Expands Dissemination Channels

Digitalized diverse platforms have broken through the geographical and temporal constraints of traditional music, significantly expanding its dissemination space. Short video platforms have become an important window for showcasing traditional music. Videos of traditional instrument performances, such as erhu and pipa, uploaded by folk artists reach global audiences quickly through algorithmic recommendations.

(3) Innovation: Artificial Intelligence Drives Traditional Music Innovation

The development of artificial intelligence technology has brought unprecedented possibilities to music composition, performance, and interpretation. AI can analyze vast amounts of music data and learn musical patterns to simulate musicians' playing styles and techniques, rendering classic works in a pleasing and melodious manner. The application of this technology not only protects and preserves traditional music but also drives innovation and diversity in musical performances.

2.3.2. Educational and teaching heritage

(1) Deepen the integration of technology and education to build an intelligent teaching system.

Colleges and universities should promote the comprehensive penetration of artificial intelligence technology, incorporating it into all aspects of music education to achieve intelligent upgrades in resource allocation, teaching implementation, and learning evaluation.

First, in terms of teaching content, teachers can utilize big data analysis to build a multi-dimensional music resource library covering both theory and practice, providing students with high-quality learning materials.

Second, in terms of teaching tools, intelligent practice systems, virtual orchestras, and intelligent scoring systems can be introduced to enhance the interactivity and precision of teaching.

Third, universities should strengthen the alignment between educational needs and technological development, driving technological innovation based on teaching requirements to ensure that artificial intelligence technology truly serves the practical needs of music education.

Fourth, universities should focus on the innovation of teaching models supported by technology, and through a combination of online and offline blended teaching methods, give full play to the advantages of artificial intelligence in improving teaching efficiency and educational equity, and fundamentally promote the comprehensive improvement of music education quality.

(2) Optimize personalized teaching paths and give full play to the advantages of teaching according to individual aptitude

Teachers should make full use of the technological advantages of artificial intelligence to create personalized teaching paths.

First, use AI technology to monitor and analyze student learning behavior in real time, accurately identify each student's learning needs, ability levels, and knowledge gaps, and tailor learning plans for them.

Second, universities can use AI technology to develop adaptive learning platforms that provide students with personalized learning paths covering multiple aspects such as music theory, skill training, and creative practice.

Third, in the process of creating personalized teaching paths, teachers should focus on students' learning experiences and sense of participation to stimulate their interest and initiative in learning. This requires not only precise technical support but also teachers playing the role of “guides” and “supervisors” in the teaching process to provide students with both emotional and professional support.

Fourth, distributed computing and dynamic resource allocation should be adopted to enhance the concurrent processing capabilities of artificial intelligence systems and ensure response speed when multiple users are present.

(3) Enhancing teachers' information literacy and constructing a technology-enabled teaching capability system

First, universities should establish systematic training mechanisms to help music teachers master the basic principles and application methods of artificial intelligence technology, enabling them to flexibly utilize intelligent tools in teaching.

Second, schools should establish collaborative learning and exchange platforms for teachers, encouraging them to share their experiences and innovative achievements in applying artificial intelligence technology in teaching.

Third, universities should eliminate teachers' concerns about the “substitutive” nature of artificial

intelligence through publicity and guidance, enhance their recognition and acceptance of technology-enabled teaching, and thereby promote the in-depth application of artificial intelligence in teaching.

(4) Strengthen data security management and build an artificial intelligence ethics protection system

The application of artificial intelligence technology requires the collection of a large amount of student behavior data and teaching process data. The secure management of this data is directly related to the protection of student privacy and school management standards.

3. Digital preservation and inheritance of traditional Chinese music culture

3.1. Design of a Blockchain-Based Digital Sharing Model for Traditional Music

3.1.1. Blockchain Platform Design Objectives

To address issues that neither traditional Chinese music culture preservation nor existing blockchain-based sharing platforms have resolved—namely, the lack of review for the originality and compliance of traditional Chinese music culture preservation content, oversight and accountability before and after infringement incidents, and insufficient blockchain storage capacity [36-37]. While addressing the limitations in permission control mechanisms present in both centralized and decentralized blockchain platforms, this design integrates the service requirements from the value chain activities of traditional Chinese music culture inheritance. The objective of designing a blockchain-based traditional Chinese music culture sharing platform is to establish a new copyright management model that integrates the following services: "controlled participant access permissions, copyright registration for original traditional Chinese music culture inheritance, effective sharing and secure transactions, efficient large-scale data storage, and high-engagement and reliable copyright supervision." Specific objectives are as follows:

(1) Controlled participant access permission objective: While meeting the platform's decentralization requirements, ensure that platform participants have different access permissions while protecting user privacy.

(2) Original copyright registration for the inheritance of traditional Chinese music culture objective: Strictly review and verify the originality of the inheritance of traditional Chinese music culture, as well as the qualifications, legality, and compliance of copyright registration institutions, to ensure that the traditional Chinese music culture sharing platform produces and outputs high-quality traditional Chinese music culture works.

(3) Effective sharing and secure transaction objectives: Fully grant creators of traditional Chinese music culture inheritance control over their copyrights, allowing flexible definition and setting of transaction terms and rules to achieve flexible and secure copyright transactions.

(4) Efficient and Large-Scale Data Storage Objective: Address the limited storage capacity of blockchain platforms to meet the requirements for the large-scale and rapid generation and storage of Chinese traditional music culture.

(5) High Participation and Reliable Copyright Oversight Objective: Actively participate in regulatory activities across all stages of the sharing and circulation of Chinese traditional music culture to ensure reliable oversight of rights confirmation, rights usage, and rights protection.

3.1.2. System Architecture of a Consortium Blockchain Platform

A blockchain-based digital content sharing platform for Chinese traditional music culture is built on the system architecture of consortium blockchain technology, integrated with the use of the IPFS distributed file storage system, to establish a consortium blockchain network. The construction of the consortium blockchain network integrates the participating members of the Chinese traditional music culture value chain activities, aligns with the operational rules of the Chinese traditional music culture inheritance and sharing process, designs and deploys corresponding smart contracts, and forms a consortium blockchain network to provide services for users of Chinese traditional music culture inheritance.

The blockchain-based traditional Chinese music culture sharing platform connects user clients with node institutions within the consortium blockchain network to provide services to users engaged in the inheritance of traditional Chinese music culture. Using consortium blockchain as the underlying technological foundation, the platform is structured from the bottom up into the following layers: storage layer, data layer, channel layer, network layer, consensus layer, contract layer, service layer, application layer, and user layer.

3.1.3. Platform Functionality Service Module Design

Based on the network structure of the consortium blockchain and the functional requirements of platform users, this paper specifically divides the designed platform into the following functional service modules to illustrate the specific services provided by the platform to users.

The functional modules of the Chinese Traditional Music Culture Heritage Platform are shown in Figure 1. The user management module primarily provides users with functions such as registration and login, user role and permission allocation, user attribute key generation, user digital certificates, and user information maintenance. The Copyright Registration Module primarily provides users with functions such as copyright registration certification, copyright originality detection, and copyright information verification. The IPFS File Storage Management Module primarily stores user identity information, copyright registration information, transaction information, and the storage of original data content related to Chinese traditional music culture. The Copyright Sharing and Transaction Module primarily provides users with functions such as copyright sharing, copyright transactions, and transaction data queries. The Copyright Supervision Module primarily provides users with functions such as infringement monitoring, infringement analysis, infringement evidence collection, and agency rights protection.

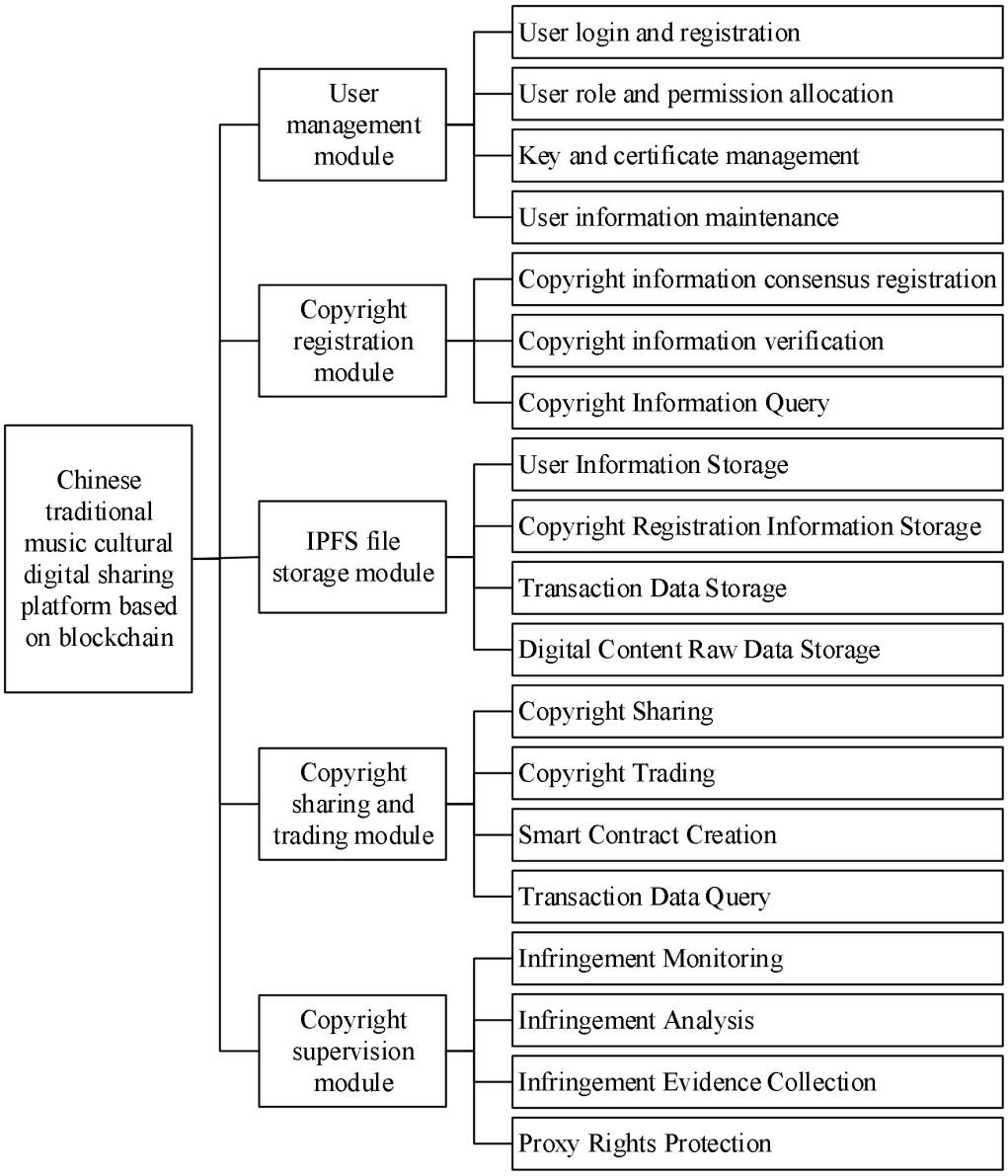

Figure 1. Chinese traditional music cultural heritage platform function module.

3.2. Copyright Protection of Traditional Chinese Music Cultural Resources

3.2.1. Hash Functions

Cryptography is the foundation of blockchain system security. Blockchain uses cryptographic technologies such as hash functions and digital signatures to ensure the security of blockchain systems.

The hash function $H(\cdot)$ is also known as a hash or hash function. It generally has the following characteristics:

Compressibility: $H(in)=out$, where in represents an input of any size and out represents a fixed-size output.

Computability: Within a reasonable amount of time, the value $H(in)$ can be effectively calculated from the input value in.

One-way property: Only out can be calculated from in. In other words, within a reasonable amount of time, it is computationally infeasible to find in that satisfies $H(in)=out$ given out.

Collision resistance: Given in_1, it is computationally infeasible to find in_2 such that $H(in_1)=H(in_2)$, where $in_1 \neq in_2$.

Chameleon hash is a trapdoor cryptographic hash function: without the trapdoor, it is difficult to find collisions, but with the trapdoor information, collisions can be generated efficiently. The Chameleon hash function consists of a set of efficient algorithms $CH=(HGen, Hash, HVer, HCol)$, as follows:

$HGen(1^{\lambda}) \rightarrow (hk, tk)$: This algorithm takes λ as the security parameter input and returns the public hash key hk and the secret trapdoor key tk.

$Hash(hk, M) \rightarrow (h, r)$: The probabilistic hash algorithm $Hash$ takes the hash key hk and the message $M \in \mathbb{M}$ as input, and outputs a pair (h, r) containing the hash value h and the verification string r.

$HVer(hk, M, (h, r)) \rightarrow (d)$: The deterministic verification algorithm $HVer$ takes the message $M \in \mathbb{M}$, the hash value h, and the verification string r as input. If (h, r) is a valid hash/verification, it returns $d=1$ (otherwise, $d=0$).

$HCol(tk, (M, h, r), M') \rightarrow (r')$: The probabilistic collision detection algorithm $HCol$ takes trapdoor key tk, valid tuple (M, h, r), and a new message $M' \in \mathbb{M}$ as input, returns a new verification string r' such that $HVer(hk, M, (h, r)) = HVer(hk, M', (h, r')) = 1$. If (h, r) is not a valid hash/verification pair for message M, the algorithm returns $\perp$.

Let $CH=(HGen, Hash, HVer, HCol)$ be a chameleon hash function with message space $\mathbb{M}$. If, for all $M \in \mathbb{M}$, there exists a negligible function $v()$ such that:

$$\Pr[HVer(hk, M, (h, r)) = 1 : Hash(hk, M) \rightarrow (h, r) \\ HGen(1^{\lambda}) \rightarrow (hk, tk)] \geq 1 - v(\lambda) \tag{1}$$

Then CH satisfies correctness.

3.2.2. Blockchain Cross-Chain Technology

Cross-chain technology refers to the technology that enables interoperability between different blockchain networks. Through cross-chain technology, information and digital assets can be transferred between different blockchain networks. Since each blockchain network typically has its own rules, protocols, and assets, cross-chain technology enables interoperability and data exchange between different blockchain networks.

Interoperability refers to the ability of different systems and institutions to work together. In the context of blockchain, interoperability generally refers to the ability of different blockchain networks to exchange, share, and collaborate on data and assets.

Cross-chain technology can address the following needs:

(1) Data sharing: Cross-chain technology enables different blockchains to share and transmit data, facilitating cross-chain communication. This is crucial for cross-chain applications and services, as they can leverage data sources from multiple blockchains and integrate them into a unified environment.

(2) Asset exchange: Cross-chain technology allows assets on different blockchains to be exchanged

and transferred, enabling users to use and transfer their digital assets across different blockchains, thereby enhancing asset liquidity and flexibility.

(3) Scalability and Performance Enhancement: Through cross-chain technology, the scalability and performance advantages of different blockchain networks can be leveraged to achieve functional expansion and performance enhancement. For example, cross-chain technology can be used to achieve functional integration, interaction, and supplementation, enabling mutual access to each other's capabilities to achieve more robust functionality. Additionally, computationally intensive tasks and transactions can be performed on one blockchain, while other blockchains handle other tasks, thereby improving the overall system's throughput and efficiency.

A blockchain cross-chain protocol is a set of specifications and protocols that define the rules, standards, data formats, and consensus protocols involved in cross-chain processes. Cross-chain protocols enabling data interoperability, value interoperability, and functional interoperability in cross-chain scenarios can be summarized as cross-chain communication protocols, cross-chain asset transaction protocols, and cross-chain smart contract invocation protocols.

Cross-chain technology provides solutions for interoperability and collaboration between different blockchain networks, serving as a key means to break down information silos across different blockchain platforms. It also creates a more seamless and rich blockchain ecosystem for users and developers, making it an important pathway for the broader adoption of blockchain technology.

Currently, mainstream cross-chain technology solutions primarily include hash locking, distributed private key control, sidechains, relays, and notary mechanisms.

The relay mechanism leverages a trusted third party but does not fully rely on it, instead using an intermediary to collect data from different blockchains for state verification. When a parallel chain needs to perform cross-chain operations, it must send the cross-chain interoperability transaction information to the relay chain for verification, which then transmits this information to the target parallel chain, thereby achieving cross-chain interoperability.

3.2.3. Cross-chain-based copyright protection scheme for music cultural resources

This chapter proposes a cross-chain-based multimedia resource copyright trustworthiness verification scheme, which aims to improve the efficiency and trustworthiness of copyright integrity, correctness, and ownership verification in a cross-chain model.

The main meanings of all symbols and their definitions are shown in Table 1.

Table 1. The main meanings of all symbols and their definitions.

Symbol	Meaning
DCI_{cp}	The only identifier of the copyright
ID_{owner}	User's only identity
ACC	The cumulative value of the copyright
ω_i	Copyright verification
set, set_i	The collection of copyright and the i element in the collection
C_{com}, C_{re}	Copyright sellers and buyers
Sk_{sign}, Pk_{sign}	SGX's and private keys
sig	SGX signature
Req	Result report of user request generation
abs	Summary of content
t_i	All transactions in the i block

This section primarily introduces how to ensure the integrity of multimedia resource copyrights in a single chain, with users able to verify the integrity of copyrights through smart contracts. Additionally, by utilizing an accumulator algorithm to accumulate copyright ownership across multiple distributions, verification of ownership can be performed without the need to search through each block individually, instead relying on simple calculations to validate the authenticity of the copyright owner.

Before transaction parties reach a transaction agreement, it is necessary to confirm whether the data owner is the genuine copyright holder. The accumulator algorithm can be used to process all copyright information and its owners. The accumulator algorithm is an effective algorithm for processing data

streams and calculating cumulative values. In the context of copyright transactions, all copyright and owner information can be constructed into a data stream, and the accumulator algorithm can be used to dynamically update and maintain the cumulative state of this information. That is:

$$set = \{Data_1 : DataOwner_1, Data_2 : DataOwner_2 \cdots, Data_i : DataOwner_i, \cdots\} \tag{2}$$

By setting a security parameter 1^{λ}, a common parameter $Para = (q, \grave{I}_1, \grave{I}_2, \grave{I}_T, e, g_1, g_2, H, H')$ is generated through a bilinear mapping $e: \grave{I}_1 \times \grave{I}_2 \to \grave{I}_T$, where $H: N \to Z_q$, $H': \grave{I}_1 \to \grave{I}_1$, and g_1, g_2 are generators of $\grave{I}_1, \grave{I}_2$. A cumulative value ACC is generated for the copyright information:

$$ACC = g^{\prod_{i=1}^{n}(set_i+\alpha)} \tag{3}$$

Where $\alpha \in Z_q$ and n is the number of copyrights in the copyright set.

To verify whether the copyright $set_i = (Data_i : DataOwner_i)$ belongs to the copyright set set, a verification value must be generated for the copyright. That is:

$$\omega_i = g^{\prod_{s \in set \wedge \{set_i\}}(s+\alpha)} \tag{4}$$

$$\omega_i = ACC^{\frac{1}{set_i+\alpha}} \tag{5}$$

After generating the verification value, for copyright set_i, it is only necessary to verify whether the following equation holds true. If it holds true, then copyright $set_i \in set$. That is:

$$e(ACC, g) = e(\omega_i, g^{set_i} g_1) \tag{6}$$

When the copyright set changes, i.e., when a user registers a new copyright, the cumulative value needs to be updated. There is no need to recalculate the entire copyright set; simply updating the cumulative value is sufficient to add the new copyright set_j to the copyright set $set_{new} = set \cup \{set_j\}$. That is:

$$ACC_{new} = g^{\prod_{i=1, i\neq j}^{n}(set_i+\alpha)\cdot(set_j+\alpha)} = ACC^{(set_j+\alpha)} \tag{7}$$

At the same time, only the update verification value ω_i needs to be verified. That is:

$$\omega_{inew} = ACC \cdot \omega_i^{\frac{1}{set_j - set_i}} \tag{8}$$

To remove copyright set_k from the copyright set, it is only necessary to update the cumulative value ACC to remove copyright set_k from the copyright set $set'_{new} = set \setminus \{set_k\}$. That is:

$$ACC'_{new} = ACC^{\frac{1}{set_k+\alpha}} \tag{9}$$

At the same time, only the update verification value ω_i needs to be verified. That is:

$$\omega'_{inew} = \omega_i^{\frac{1}{set_k+\alpha}} = \left(\frac{\omega_i}{ACC'_{new}}\right)^{\frac{1}{set_k - set_i}} \tag{10}$$

Algorithm for updating cumulative value during copyright transactions: When a copyright owner transfers copyright, the purchaser obtains ownership of the copyright, so it is necessary to revoke the original copyright owner's ownership and add the new copyright owner. When the original copyright owner C_{com} transfers the copyright $data_{tra}$ to C_{re}, the system first verifies whether C_{com} owns the copyright $data_{tra}$ to ensure that the transaction does not result in a copyright dispute. Then, the ownership of C_{com} is revoked, and the cumulative value of the copyright is updated using formula (9), while the verification value ω_i is updated using formula (10). Finally, the owner of copyright $data_{tra}$ is

updated to C_{re} , and the copyright $(C_{re}, data_{tra})$ is added to the copyright set using formula (7), updating the cumulative value and verification value.

The specific steps for trusted cross-chain verification are as follows:

Step 1: The requester in blockchain A initiates a cross-chain $Request$ request and uploads it to blockchain A . The random number $nonce$ is used to prevent replay attacks. That is:

$$Request = \left[Challenge \middle| nonce_r \right] \tag{11}$$

Step 2: Full nodes with TEE in blockchain A that receive the $Request$ request will forward the request to the Application Enclave. Upon receiving the request, the Application Enclave calls the corresponding API in TEE to handle the $Challenge$, generates a report Rep , and generates a summary abs , and sends them to the Quoting Enclave. That is:

$$MS = \left[Rep \middle| abs \right] \tag{12}$$

Step 3: After receiving MS , Quoting Enclave uses the private key SK_{sign} to sign it and generate Sig_{QE} , creating a proof report, which is then sent to the full node. That is:

$$Rep_{QE} = \left[Challenge \middle| Rep \middle| ads \middle| Sig_{QE} \middle| nonce_{QE} \right] \tag{13}$$

Step 4: Full nodes on blockchain A broadcast the report Rep_{QE} on the relay chain. Nodes on blockchain B responsible for monitoring the relay chain detect that the report Rep_{QE} is a request for transactions on this chain. Full nodes on blockchain B with TEE first authenticate the signature in Rep_{QE} through the certification authority, then repeat Step 2 for the Rep_{QE} report, calling the relevant API in TEE to run the smart contract to process the request. At the same time, they generate the Rep'_{AE} report and the abs'_{AE} summary. That is:

$$MS'_{AE} = \left[Rep'_{AE} \middle| abs'_{AE} \right] \tag{14}$$

Step 5: The Application Enclave of the full node in the blockchain B sends MS'_{AE} to the Quoting Enclave, signs it with the private key SK'_{sign} to generate Sig'_{QE} , generates a proof report, and sends the report to the full node A . That is:

$$Rep'_{QE} = \left[Challenge \middle| Rep'_{AE} \middle| abs'_{AE} \middle| Sig'_{QE} \middle| Rep_{QE} \right] \tag{15}$$

Step 6: Full nodes on blockchain B send reports to full nodes on blockchain A . Full nodes on blockchain A confirm the signature Sig'_{QE} through the certification authority. If the full nodes on blockchain B execute the corresponding code in the TEE, they send Rep'_{QE} to the lightweight nodes. Lightweight nodes can use the public keys Pk_{sign} and Pk'_{sign} to verify the signatures Sig_{QE} and Sig'_{QE} at the certification authority. Once verification is successful, it can be ensured that the corresponding request is correctly executed within the TEE.

3.2.4. Digital Resource Copyright Protection Testing

This paper integrates blockchain cross-chain technology with traditional Chinese music cultural resources copyright protection schemes to design a blockchain-based digital copyright protection and transaction system for traditional Chinese music culture. This system can conveniently determine the copyright of creators while enabling secure transactions between creators and copyright purchasers. This scheme adopts Hyperledger Fabric (abbreviated as Fabric) as the underlying framework for the blockchain, incorporates the concept of anonymous communication systems, and leverages the advantages of cross-chain technology to design a blockchain-based digital copyright protection and transaction system for traditional Chinese music culture. The digital copyright protection and transaction system for traditional Chinese music culture is an indispensable measure for the inheritance and development of traditional Chinese music culture.

The client-side of this system is a web application, allowing users to access and utilize platform

functions via a browser. The server-side development environment is deployed on a Linux operating system, with Fabric serving as the underlying platform for the consortium blockchain. Since the platform in Fabric is implemented using the Go programming language, the backend is developed in Go, with the open framework utilizing Gin, ensuring better compatibility and higher execution efficiency. For backend and underlying blockchain calls, the fabric-sdk-go library is used, which provides a rich set of methods for interacting with the Fabric consortium blockchain. Chaincode development utilizes the Shim API to retrieve transaction content. Deployment employs a Docker containerization approach, packaging the existing environment into an image and using Docker Compose to configure the network environment.

(1) Cross-chain performance testing

For the cross-chain module, this section provides specific scenario-based stress testing. The relay chain has 8 nodes, and the Caliper stress testing tool is used to continuously generate transaction requests. The consensus algorithm used is PBFT. Within five minutes, transaction counts and transaction rates are monitored at 30-second intervals, with an average throughput of 200 TPS. The results of the cross-chain transaction stress test are shown in Figure 2.

Additionally, specific testing methods are provided for cross-chain transaction latency. First, a test script is written to simulate real user behavior. The program records the time from initiating a cross-chain transaction to receiving the response result, with an average latency of 3.1 seconds.

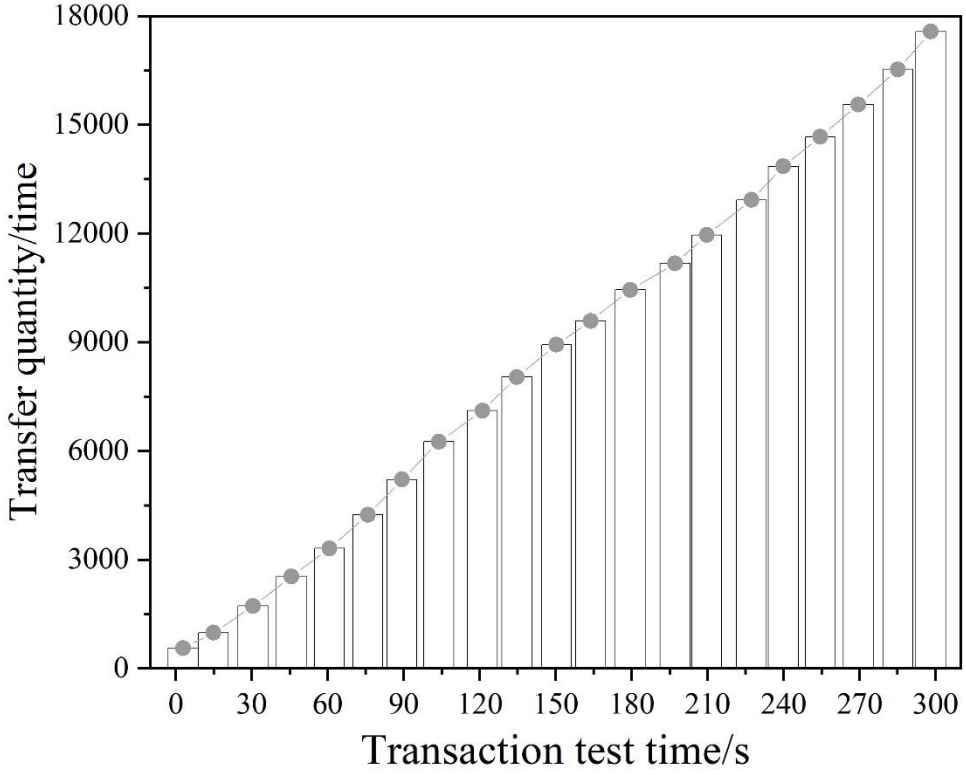

Figure 2. Cross-chain transaction stress test results.

(2) Security Testing

DOS Attack Resistance: Here, we simulate an attacker launching a DOS attack on the copyright protection and transaction system and verify whether the system can withstand the DOS attack.

Experiment Description: Since the blockchain system is a distributed architecture, it has the ability to tolerate the failure of a single node. This attack uses Hyperledger Caliper to perform read/write stress tests on Fabric smart contracts and observe the system's load status.

Test environment: The Fabric network uses the system's default network. In the first round, two attackers continuously read and write smart contracts for 120 seconds, and the system's performance is observed.

Simultaneously, Prometheus+Grafana is used to visualize the system's operational status. This paper provides CPU usage, memory information, network bandwidth information, and disk read/write information for the attacked nodes.

The CPU load situation is shown in Figure 3. The peak CPU usage rate during the DOS attack was

approximately 98%, with significant fluctuations in usage rates occurring between 18:40 and 18:45.

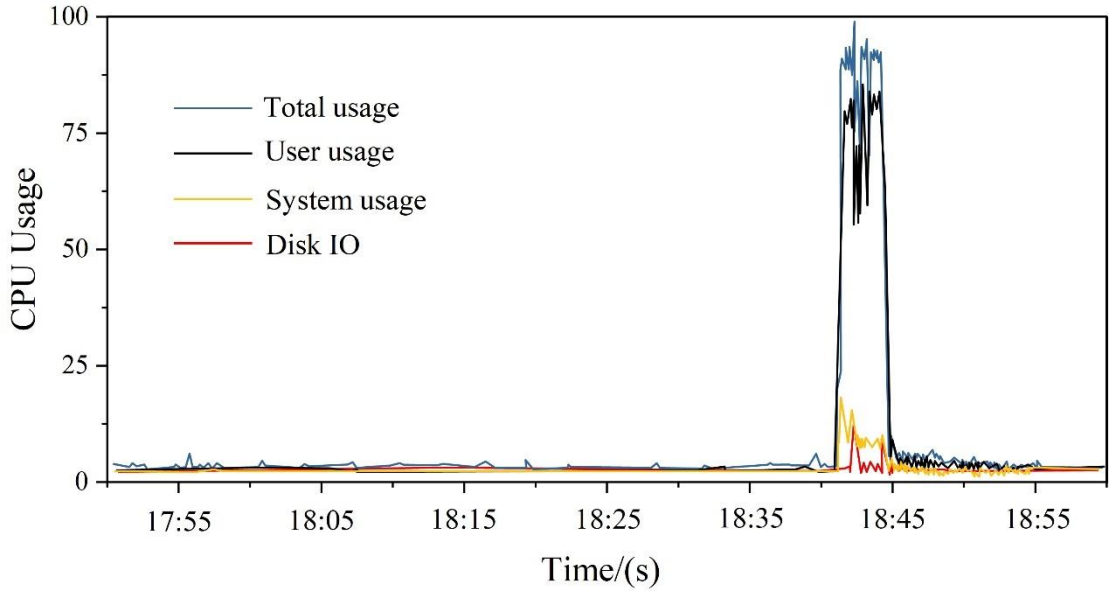

Figure 3. CPU load condition.

The disk read/write status is shown in Figure 4, with the hard disk write speed below 25MB/s.

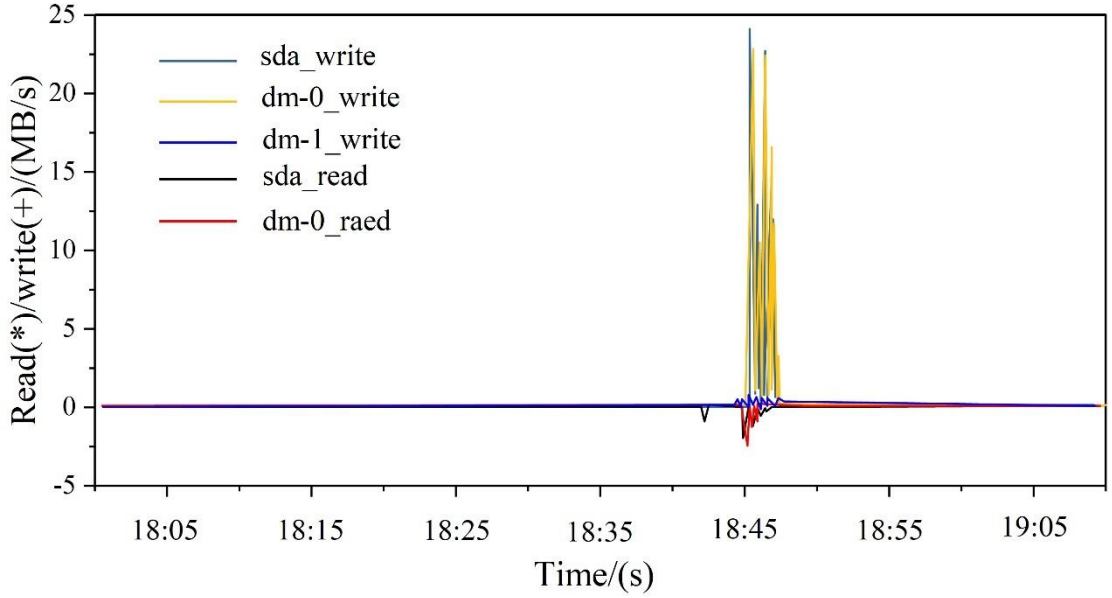

Figure 4. Disk literacy.

Memory usage is shown in Table 2, with the highest memory usage ratio being 81.40%.

Table 2. Memory occupancy.

	Min	Max	Avg	Current
Total memory	16.72GiB	16.72GiB	16.72GiB	16.72GiB
Available	3.12GiB	9.85GiB	9.13GiB	9.64GiB
Total-aval	5.79GiB	13.61GiB	6.26GiB	5.89GiB
Used	5.34GiB	12.73GiB	6.04GiB	5.52GiB
Cached	2.36GiB	2.55GiB	2.27GiB	2.11GiB
Usage(right-y)	34.63%	81.40%	37.44%	35.23%

The network bandwidth situation is shown in Figure 5. The average values of eth0_out upload and eth0_in download are approximately 19 kb/s and 2 kb/s, respectively.

The data shows that during the attack, all system parameters increased, but the system continued to operate normally and returned to stability after a period of time. This indicates that the system has good defense capabilities against DOS attacks.

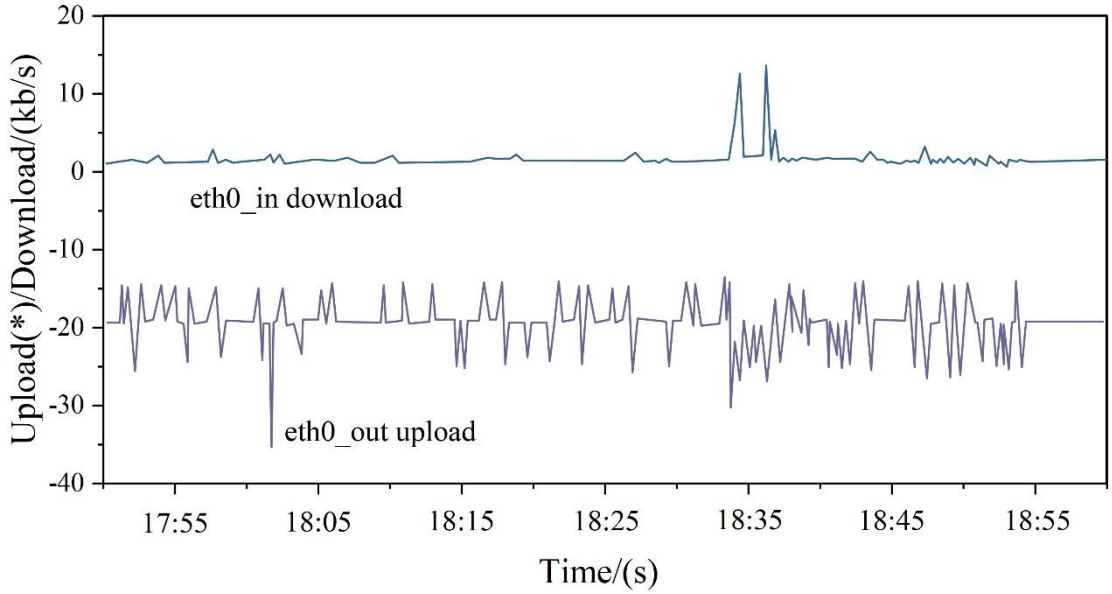

Figure 5. Network bandwidth.

3.3. Digital Teaching Development for the Preservation of Traditional Chinese Music Culture

To gain a more comprehensive understanding of how a certain school preserves and promotes traditional Chinese music culture in its educational activities, field visits were conducted to the schools under investigation during the research period to gain firsthand insights into their actual circumstances. Additionally, in addition to the four schools primarily selected for this study, field visits were also conducted to other schools in the district to investigate the basic situation of how they preserve and promote traditional Chinese music culture in their educational activities.

A total of 500 questionnaires were distributed, with 483 returned, resulting in a response rate of 96.6%. Among these, 475 were valid questionnaires, yielding a validity rate of 98.34%. The valid questionnaires were entered into the SPSS 22.0 system for organization and analysis.

The development of the inheritance and promotion of traditional Chinese music culture in schools is shown in Table 3. 1-5 represent extremely unnecessary, somewhat unnecessary, average, relatively necessary, and very necessary, respectively.

57.68% of students recognized the integration and inheritance of traditional Chinese music culture in classroom teaching. Teachers utilized digital technology (such as multimedia technology) to play, share, appreciate, and interpret traditional Chinese music culture, updating students' understanding of traditional Chinese music culture together with them during class time.

48.21% of students very much like and 21.26% of students somewhat like learning about traditional Chinese music culture in extracurricular activities.

In the survey data on the perceived necessity of inheriting traditional Chinese music culture and willingness to further study it, only 2% of students believe that inheriting traditional Chinese music culture is meaningless and are extremely uninterested in its development and inheritance.

Table 3. The traditional music culture of China inherits the development of school.

	Options	5	4	3	2	1	Total
The understanding of the necessity of inheritance	N	121	174	156	15	9	475
	(%)	25.47	36.63	32.84	3.16	1.89	100.00
Willing to study further	N	175	119	139	36	6	475
	(%)	36.84	25.05	29.26	7.58	1.26	100.00
The passing effect of classroom teaching	N	274	112	52	32	5	475
	(%)	57.68	23.58	10.95	6.74	1.05	100.00

The inheritance of extracurricular activities	N	229	101	99	42	4	475
	(%)	48.21	21.26	20.84	8.84	0.84	100.00

The results of the survey on the diverse forms of inheritance of traditional Chinese music culture in school educational activities are shown in Table 4. The forms of inheritance of traditional Chinese music culture in educational activities are rich and varied, which can arouse students' interest and encourage them to participate in related activities more actively and voluntarily, rather than out of obligation to school requirements. The effects of these two approaches are fundamentally different, so it is essential to pay attention to the forms of extracurricular activities. Students enjoy learning about and sharing traditional Chinese music culture through festival celebrations, themed activities, club activities, and flag-raising ceremonies.

Table 4. The various forms of Chinese traditional music culture are carried out.

Education activity	(%)	5	4	3	2	1	Total
Flag-raising	(%)	175	129	104	56	11	475
Festival celebration	(%)	279	104	69	20	3	475
Singing classic	(%)	105	175	112	74	9	475
Club activities	(%)	176	152	85	57	5	475
Theme activity	(%)	165	144	107	52	7	475
Subject line	(%)	187	134	68	80	6	475
Singing match	(%)	124	151	91	68	41	475
Other forms	(%)	175	129	104	56	11	475

4. Conclusion

This paper integrates the requirements for the intelligent inheritance of traditional Chinese music culture with the key points for the inheritance and development of traditional Chinese music culture within the education system. It proposes and designs a digital sharing solution for the inheritance of traditional Chinese music culture based on blockchain technology. By utilizing blockchain cross-chain technology, this solution safeguards the copyright of traditional Chinese music culture resources and promotes the positive inheritance of traditional Chinese music culture.

The average latency of the digital sharing system integrating copyright protection for traditional Chinese music cultural resources is 3.1 seconds, with a peak CPU usage rate of approximately 98% during a DOS attack, hard disk write speeds below 25 MB/s, and memory usage peaking at 81.40%. The system designed in this paper meets the needs for the inheritance and development of traditional Chinese music culture.

Over 60% of students recognize the necessity of inheriting traditional Chinese music culture, and 81.26% of students approve of integrating traditional Chinese music culture into classroom teaching activities, preferring teachers to use multimedia and other digital technologies to disseminate and share traditional Chinese music culture. More than half of the students prefer to learn about traditional Chinese music culture in festive celebrations, themed activities, and club events. Therefore, themed activities can be conducted in school educational activities by combining the digital form of traditional Chinese music culture, thereby updating the pathways for its inheritance.

References

1. Antoshko, M. (2020). Chinese musical traditions: stages of development. Culture and arts in the modern world, 11.
2. Lei, Q. (2025). Comment on “Integration of traditional Chinese music: an evaluation of the interactive influence between traditional music and aesthetic thought”. Trans/Form/Ação, 48(3), e025079.
3. Xia, W. (2022). Peculiarities of singing in Chinese popular and traditional music: Influence of musical genres on vocals. Música Hodie, 22.
4. Chen, J., Tang, X., Xie, T., Wang, J., Dong, W., & Shi, B. (2025, April). MusicMamba: A Dual-Feature Modeling Approach for Generating Chinese Traditional Music with Modal Precision. In ICASSP 2025-2025 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP) (pp. 1-5). IEEE.
5. Wang, H. (2024). Moral thought: evaluation on the moral education and virtue cultivation of traditional Chinese music. Trans/Form/Ação, 47(5), e02400167.
6. Yunfan, Y., Charoensloong, T., & Yukolthonwong, S. (2024). The Influence of Western Music on Chinese Music and the Current Situation of Chinese Vocal Music in China. Journal of Modern Learning Development, 9(4), 586-594.

7. Liu, H. (2016, May). Research on the development trend of Chinese traditional music art from the perspectives of aesthetic and historical culture. In 2016 2nd International Conference on Social Science and Technology Education (ICSSTE 2016) (pp. 171-175). Atlantis Press.
8. Zhang, L. (2024, December). Research on the Positioning of Traditional Chinese Music in Music Classroom Teaching in Ordinary Colleges and Universities. In 2024 7th International Conference on Humanities Education and Social Sciences (ICHESS 2024) (pp. 241-251). Atlantis Press.
9. Shi, J. (2025). Exploring the Role of Traditional Music in Cultural Education: A Case of Integrated Music Curriculum in China. Mediterranean Archaeology and Archaeometry, 25(2).
10. Li, J., Onlamul, K., You, L., & Yang, F. (2024). Transmission Guidelines for Literacy Studies in Si Zhu Yue Traditional Chinese Folk Music. International Journal of Education and Literacy Studies, 12(2), 80-86.
11. Luo, J. (2018, July). Discussion on the inheritance, integration and promotion of Chinese traditional folk music culture in college piano education. In 2018 International Conference on Education Science and Social Development (ESSD 2018) (pp. 122-124). Atlantis Press.
12. Rui, L. (2025). Historical evolution of Chinese music aesthetics in the digital age. Digital Scholarship in the Humanities, fqaf041.
13. Wei, S. (2023). Research on the application of big data analysis in music enterprises. Academic Journal of Business & Management, 5(16), 46-51.
14. Ahlers, M., Grünewald-Schukalla, L., Lücke, M., & Rauch, M. (Eds.). (2019). Big Data und Musik. Springer vs.
15. Wang, S., & Lou, G. (2023, August). Data Construction of Music Culture Communication Based on Data Mining Technology. In EAI International Conference, BigIoT-EDU (pp. 193-200). Cham: Springer Nature Switzerland.
16. Ren, J. (2025). Inheritance and protection of intangible cultural heritage in drama category based on AI human–computer interaction and digital technology. Discover Artificial Intelligence, 5(1), 1-16.
17. Wang, Q., & Shen, S. (2018, January). Digital inheritance strategy of intangible cultural heritage and big data model-taking the southern liaoning Province as an example. In 2018 International Conference on Intelligent Transportation, Big Data & Smart City (ICITBS) (pp. 295-298). IEEE.
18. Herlihy, D., & Zhang, Y. (2016). Music industry and copyright protection in the United States and China. Global Media and China, 1(4), 390-400.
19. Guo, Z., Wang, D., & Li, Z. (2025). Cultural Tourism Economy and Cultural Heritage of National Music and Dance Bases under the Integration of Digital Intelligence, Industry and Education. Journal of Education, Humanities, and Social Research, 2(3), 43-54.
20. Chen, Y. (2020). Research on the protection and inheritance of opera art in linchuan area based on the effectiveness analysis of witch elements in big data era. In E3S Web of Conferences (Vol. 218, p. 04031). EDP Sciences.
21. Fan, J. (2023). Innovation and Exploration of the Path to Cultivating University Students' Cultural Awareness through New Media in the Context of Cultural Inheritance. Media and Communication Research, 4(11), 61-70.
22. He, P. (2020, April). Research on the clarinet music based on big data. In Journal of Physics: Conference Series (Vol. 1533, No. 4, p. 042034). IOP Publishing.
23. Liao, Y. (2024). The fusion of tradition and modernity: a study on the development of Hunan Flower Drum Opera from the perspective of" living heritage". Journal of Ecohumanism, 3(8), 3675-3687.
24. Sun, L., & Wang, Q. (2024). Music teaching strategy and educational resource sharing based on big data. Journal of Computational Methods in Science and Engineering, 24(4-5), 2391-2407.
25. Wang, J., & Zheng, H. (2025). Exploration of Reform and Development Countermeasures of Music Education in the Context of Big Data Education Culture. Cultura: International Journal of Philosophy of Culture and Axiology, 22(2), 209-227.
26. Min, S. (2025). Application of big data analysis in optimizing music education. Journal of Computational Methods in Sciences and Engineering, 25(1), 987-1001.
27. Ma, L. (2019). Traditional music protection system from the ecological perspective based on big data analysis. Ekoloji Dergisi, (107).
28. Lin, Y. (2020, October). Research on the Development Strategy of Guangfu Traditional Music Culture Based on Big Data. In 2020 2nd International Conference on Machine Learning, Big Data and Business Intelligence (MLBDBI) (pp. 278-282). IEEE.
29. Chang, W. (2025). The integration of artificial intelligence and ethnic music cultural inheritance under deep learning. Computer Science and Information Systems, (00), 36-36.
30. Yan, J. (2025). Innovative Cultural Transmission Paths Analysis for Local Opera Based on Data Mining. International Journal of High Speed Electronics and Systems, 34(02), 2440027.
31. Li, F. (2020, April). Aesthetic trend of folk vocal music under the influence of big data thinking. In 2020 International Conference on Big Data and Informatization Education (ICBDIE) (pp. 96-98). IEEE.
32. Chen, D., Sun, N., Lee, J. H., Zou, C., & Jeon, W. S. (2024). Digital Technology in Cultural Heritage: Construction and Evaluation Methods of AI-Based Ethnic Music Dataset. Applied Sciences, 14(23), 10811.
33. Sun, Z. (2020, October). Analysis of the inheritance of traditional music culture based on big data auxiliary technology. In Journal of Physics: Conference Series (Vol. 1648, No. 4, p. 042029). IOP Publishing.
34. Darlenis, T. (2022). Internet-era patterns of protection and inheritance methods for Minangkabau talempong pacik music. International Journal of Visual and Performing Arts, 4(1), 47-52.

35. LuYin & RuosiGuo. (2024). An Artificial Intelligence-Based Interactive Learning Environment for Music Education in China: Traditional Chinese Music and Its Contemporary Development as a Way to Increase Cultural Capital. European Journal of Education,60(1),e12858-e12858.
36. Gamage Namal,Ambagala A.P. Krishni Kavindya,Nanayakkara Samudaya & Perera Srinath. (2025). Towards a framework for implementing blockchain technology in the construction industry of Sri Lanka. Built Environment Project and Asset Management,15(3),612-628.
37. Cîmpan Ioana & Crișan Emil Lucian. (2025). Blockchain concepts in business research – a scoping review. Management Matters,22(1),52-62.