

ECONOMIC VALUE CONVERSION OF INTANGIBLE CULTURAL HERITAGE BASED ON NFT DIGITAL COLLECTIBLES AND O2O OPERATION

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Abstract: This study explores how Xue Tao paper woodblock watermarking can convert cultural value into sustainable economic value through NFT digital collectibles and O2O operation. Based on project materials and survey evidence, the paper constructs a platform-oriented model that links blockchain-based ownership confirmation, digital collectible display, metaverse interaction, VR/AR craft experience, AI-assisted design, personalized recommendation, big-data operation, and offline workshops. The results indicate that public awareness of Xue Tao paper remains limited, but young users show clear interest in immersive experience, customized cultural products, and digital collectible consumption. The proposed pathway first transforms heritage works into traceable digital assets, then expands user participation through virtual creation and point-based interaction, and finally connects online traffic with offline courses, DIY production, cooperative restaurants, and campus activities. This model provides a practical route for intangible cultural heritage commercialization by integrating copyright protection, cultural communication, user payment, and continuous platform operation for sustainable cultural-industry development.

Keywords: NFT digital collectibles; Heritage economy; Asset confirmation; O2O commercialization; Cultural consumption

1 INTRODUCTION

The digital collectibles economy provides a new channel for converting intangible cultural heritage from symbolic cultural resources into traceable, tradable, and experience-based digital assets. Xue Tao paper woodblock watermarking contains craft value, literary memory, and local cultural identity, but its traditional dissemination mainly depends on physical exhibition, offline explanation, and limited hands-on participation. This makes it difficult to attract younger users, expand commercial scenarios, and form continuous asset circulation. Blockchain NFT, metaverse interaction, VR/AR immersion, AI recommendation, AIGC-assisted creation, O2O linkage, and big-data operation offer tools for rebuilding this value chain. Through these technologies, cultural content can be transformed into digital collectibles with ownership confirmation, customized creative products, immersive consumption scenes, and online-offline service flows. Therefore, the core question of this study is how to build an economic conversion path in which Xue Tao paper woodblock watermarking can be authenticated, displayed, created, circulated, consumed, and continuously operated through a platform model [1,2]. The project materials support this question from three aspects. First, the technical design describes a metaverse virtual space, VR/AR craft interaction, blockchain and NFT transaction mechanisms, AI-assisted pattern design, personalized recommendation, O2O reservation, and big-data marketing. Second, the survey results show that public awareness of Xue Tao paper remains limited, whereas technology-enabled heritage experience, NFT collections, and personalized cultural products are attractive to young users. Third, the achieved results include mini-program construction, online learning, point-mall interaction, VR-based design workshops, digital relic display, exclusive customization, social-media promotion, interactive activities, and offline cooperation. Based on these materials, this paper follows the logic of asset confirmation, experience monetization, demand verification, and operational implementation. It analyzes how NFT ownership confirmation gives heritage works digital asset attributes, how immersive and customized services increase willingness to pay, how O2O scenes connect online creation with offline workshops and commercial payment, and how survey evidence supports platform positioning. This structure highlights a practical intangible heritage economy model that integrates technology innovation, cultural communication, digital asset circulation, and sustainable commercial transformation.

2 TECHNICAL INTEGRATION AND INNOVATION

This project deeply integrates frontier technologies such as the metaverse, NFT, VR/AR, AI, and blockchain into the field of intangible cultural heritage. It forms a full-chain solution of digital creation, asset trading, and virtual-real linkage, injecting new vitality into the inheritance and promotion of Xue Tao paper woodblock watermarking and promoting its transformation from protection to sustainable operation.

2.1 Metaverse Architecture and Immersive Experience

Based on advanced game engines such as Unity and Unreal Engine, the project builds a metaverse virtual space that supports multi-user online collaborative creation. Users can experience the production process of Xue Tao paper engraving in an immersive virtual space and carry out 360-degree panoramic interaction through VR/AR technology. This immersive experience enables users to feel the unique charm of Xue Tao paper woodblock watermarking as if they were on site, while also protecting cultural relics from physical damage through virtual reality technology[3,4].

Figure 1 illustrates the metaverse mainland concept map used to present the virtual cultural scene.

Figure 2 shows the immersive experience interface for Xue Tao paper interaction.

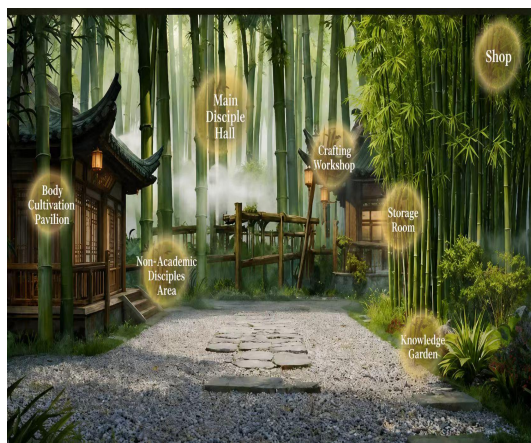


Figure 1 Metaverse Mainland Concept Map

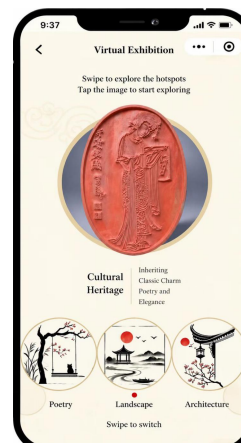


Figure 2 Immersive Experience

2.2 Blockchain and NFT-Based Asset Application of Intangible Cultural Heritage

The project builds a blockchain-based digital copyright management system and generates a unique NFT for each Xue Tao paper work, realizing ownership confirmation, traceability, and transaction. This design aims to solve the problems of unclear copyright and difficult circulation in traditional intangible cultural heritage works and promotes the transformation of intangible cultural heritage from physical collection to digital assets. This innovative application not only provides a new protection method for heritage works, but also offers a new path for the commercialization of intangible cultural heritage. This pathway is consistent with recent studies on cultural-heritage valuation, digital regeneration, and economic conversion [5-7].

2.3 AI-Driven Personalized Service and Creative Assistance

The project studies AI-driven personalized recommendation algorithms and dynamically optimizes experience content according to user behavior data, such as operation preferences and learning progress. AI technology can also assist users in designing Xue Tao paper engraving patterns, provide immersive experience in combination with VR/AR technology, generate personalized patterns according to user actions, and synchronize them to personal accounts. At the same time, AI technology can provide personalized learning suggestions and creative inspiration according to user behavior data, reducing the threshold of user creation and improving participation[8].

Figure 3 shows the AI-assisted design interface used for personalized creative support.

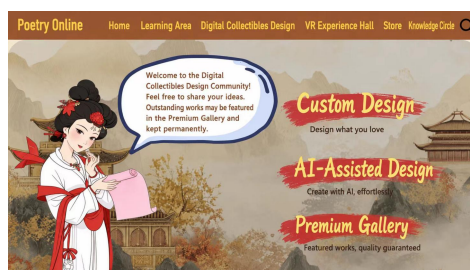


Figure 3 AI-assisted Design Interface Display

2.4 O2O Model and Big-Data-Driven Precise Operation

Through an online reservation and offline experience linkage system, the project realizes seamless switching between virtual creation and physical workshop practice. Big data analysis optimizes offline activity location selection and content design, improves communication efficiency, breaks the traditional single-line mode of intangible cultural heritage promotion, and builds user growth archives and behavior databases to realize precise marketing and cultural communication. This online-offline integration enhances user participation and promotes the dissemination and commercialization of intangible cultural heritage.

Figure 4 illustrates the O2O model structure connecting online interaction and offline experience.

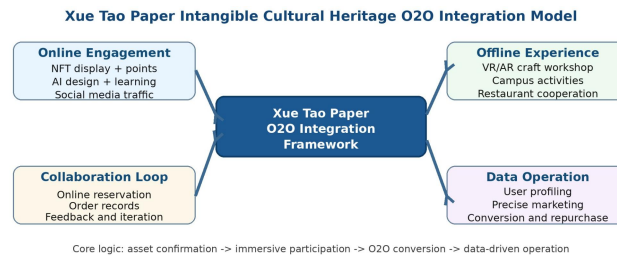


Figure 4 O2O Model Structure

3 SURVEY SITUATION

3.1 Online Survey

By designing questionnaires and widely distributing them through social media, professional forums, mailing lists, and other channels, the project collected information on public awareness of Xue Tao paper woodblock watermarking, interest in the popular elements it contains, expectations for platform construction, and preferences for product selection. Table 1 summarizes the online survey results concerning public cognition and product preference. Table 1 further presents the survey results used to support the analysis of user expectations.

Table 1 Online Survey Results Concerning Public Cognition and Product Preference

Survey item	Option	Frequency	Percentage
1. Familiarity with Xue Tao Paper	Very familiar	35	16.59%
	Generally familiar	70	33.18%
	Slightly familiar (Only heard the name)	36	17.06%
	Totally unfamiliar	70	33.18%
2. Experience with Metaverse, AR, AIGC and related products	Frequently used	49	23.22%
	Occasionally used	79	37.44%
	Rarely used	52	24.64%
	Never used	31	14.69%
3. Willingness to experience Metaverse functions in Mini Program (Multiple choices)	Virtual character interaction	172	81.52%
	AR production of Xue Tao Paper	42	19.91%
	AI poetry creation	87	41.23%
	Online poetry gatherings	44	20.85%
	Blockchain & NFT digital collectibles	26	12.32%
	Others	0	0%
4. Expectation for the combination of Metaverse, ICH and Poetry	Very excited and willing to experience immediately	42	19.91%
	Quite interested and will follow updates	97	45.97%
	Neutral, depends on actual effects	40	18.96%
	Uninterested	32	15.17%
5. Willingness to purchase commercial products (Multiple choices)	DIY kits for Xue Tao Paper	55	26.07%
	Custom cultural and creative products	98	46.45%
	NFT digital collectibles	168	79.62%
	Tickets for offline poetry activities	160	75.83%
	Unwilling to purchase any products	127	60.19%

3.2 Offline Survey

The project participated in and co-organized the Wang Chunfeng garden activity at Chengdu Wangjianglou Park, conducting field research, experience activities, and publicity for Xue Tao paper woodblock watermarking.

The project team also entered Chengdu Wangjianglou Park and the Xue Tao Memorial Hall for in-depth study. The team learned about the technical details, output products, historical background, and cultural heritage behind Xue Tao paper woodblock watermarking from multiple aspects, observed closely, and entered the cultural atmosphere. By

listening to explanations of the technique and inheritance of Xue Tao paper woodblock watermarking, the team understood the craft and reflected on market views and experience. The team learned the whole process from material preparation to finished product production, communicated about taking photos and recording materials, and confirmed the content and form of the mini-program. Through the visit to the Xue Tao Memorial Hall, the team gained a deeper understanding of the life and talent of Tang Dynasty poet Xue Tao and appreciated the unique insight into the world contained in her poems. This strengthened the direction of combining Xue Tao paper woodblock watermarking with literary culture represented by poetry.

During the survey, the project team maintained close communication and coordination with all parties to ensure the smooth promotion and implementation of cooperation. When negotiating cooperation with companies, the team revised and discussed details many times, learned more knowledge and information in the process, and improved team members in various aspects.

3.3 Survey Results

3.3.1 Public cognition and interest

Survey results show that public awareness of Xue Tao paper woodblock watermarking is relatively low. Only about 56% of respondents indicated that they had some understanding of it, and most people remained at the level of having merely heard of the technique. However, when asked about interest in experiencing intangible cultural heritage through new technologies such as the metaverse and NFT, about 60% of respondents showed strong interest, especially young groups aged 18 to 35, whose proportion exceeded 70%. This indicates that although public awareness of traditional intangible cultural heritage is limited, technology-integrated heritage experience has relatively high acceptance and expectation.

3.3.2 Acceptance of digital intangible cultural heritage products

In terms of acceptance of digital intangible cultural heritage products, survey results show that more than 60% of respondents are willing to try immersive heritage experiences through VR/AR technology, and about 40% of respondents are interested in NFT digital collections and willing to pay a certain fee for them. In addition, more than 50% of respondents believe that personalized customized intangible cultural heritage cultural and creative products are attractive. This is especially evident among Generation Z users aged 18 to 25, whose demand for personalized and customized products exceeds 70%.

3.3.3 User demand and preference

The survey further reveals user demand and preference for digital intangible cultural heritage products. At the functional level, users generally expect the platform to provide immersive experience, personalized design tools, and rich learning resources on intangible cultural heritage. At the content level, the public is interested not only in the historical background, production process, and inheritance stories of Xue Tao paper woodblock watermarking, but also in the female literary power and classical poetry culture contained in it, hoping that these contents can be presented in a vivid and interesting form. Users also expect the platform to connect online and offline interactive scenes and support online appointment for experience courses and participation in heritage cultural activities. Based on this, the project takes female power and poetry culture as core highlights and characteristic selling points to create a digital heritage experience that better fits public emotional resonance and cultural needs.

3.3.4 Market potential and challenges

From the perspective of market potential, survey results show that the intangible cultural heritage market has considerable development potential. As demand for cultural consumption continues to increase, especially among younger generations pursuing personalized products with rich cultural connotations, heritage cultural and creative products and digital heritage experiences are expected to become new cultural consumption hotspots. The survey also reveals challenges. Public awareness and participation in intangible cultural heritage still need improvement, and traditional communication methods require further innovation and optimization. Digital heritage product development and promotion also need to overcome high technical thresholds, high user education costs, and intense market competition. Overall, public cognition of traditional intangible cultural heritage is limited, but acceptance of technology-integrated heritage experiences is high; young users, especially Generation Z, show strong demand for personalized, customized, and immersive experiences; digital heritage products have strong market potential while facing cognitive, technical, and competitive challenges, which provides important reference for technical innovation and product development.

4 ACHIEVED STAGE RESULTS

4.1 Survey Achievements: Accurate Understanding of Public Cognition and Demand

4.1.1 Online survey

The project designed multidimensional questionnaires and distributed them widely through social media, professional forums, and mailing lists, covering public awareness of Xue Tao paper woodblock watermarking, platform expectations, and product preferences. Expert seminars were organized to discuss the protection, inheritance, and market development of Xue Tao paper woodblock watermarking with scholars and experts in the field. The questionnaire content was continuously updated and optimized to ensure data coherence and market adaptability.

4.1.2 Offline survey

Temporary survey stations were set up on campus, commercial streets, and Chengdu Wangjianglou Park, inviting passersby to participate in interactive questionnaire research. Cultural and creative peripheral products containing Xue Tao paper elements were provided as rewards for participants with a correction rate of more than 80%, attracting people of different ages and collecting broad and authentic opinions and suggestions. Table 2 shows the survey station used to support interactive questionnaire research.

Table 2 Survey Station Supporting Interactive Questionnaire Research

Duration	Source	Source Details	IP Location	Gender
93s	WeChat	N/A	Zaozhuang, Shandong	Male
132s	WeChat	N/A	Guangzhou, Guangdong	Male
96s	WeChat	N/A	Shijiazhuang, Hebei	Female
93s	WeChat	N/A	Cangzhou, Hebei	Male
123s	WeChat	N/A	Baoding, Hebei	Male
101s	WeChat	N/A	Chongqing	Female
82s	WeChat	N/A	Jixi, Heilongjiang	Male
125s	WeChat	N/A	Tai'an, Shandong	Female
103s	WeChat	N/A	Chongqing	Female
94s	WeChat	N/A	Beijing	Male
128s	WeChat	N/A	Lianyungang, Jiangsu	Female
89s	WeChat	N/A	Zibo, Shandong	Male
118s	WeChat	N/A	Qianjiang, Hubei	Female
121s	WeChat	N/A	Rizhao, Shandong	Female
124s	WeChat	N/A	Nanchang, Jiangxi	Male
138s	WeChat	N/A	Suzhou, Anhui	Male
114s	WeChat	N/A	Shijiazhuang, Hebei	Male
114s	WeChat	N/A	Jieyang, Guangdong	Female
94s	WeChat	N/A	Pingdingshan, Henan	Female
85s	WeChat	N/A	Binzhou, Shandong	Female
117s	WeChat	N/A	Qingdao, Shandong	Female
84s	WeChat	N/A	Beijing	Male
109s	WeChat	N/A	Shenyang, Liaoning	Female
128s	WeChat	N/A	Shenzhen, Guangdong	Male

4.2 Technical Development Achievements: Initial Formation of the Mini-Program and Platform Architecture

4.2.1 Realization of core mini-program functions

The Poetry on Paper mini-program has been built, forming an online intangible cultural heritage interaction scene. Figure 5 presents the Poetry on Paper mini-program interface. Figure 6 shows the main interface design of the Poetry on Paper mini-program.



Figure 5 Poetry on Paper Mini-program Interface



Figure 6 Main Interface Design of the Poetry on Paper Mini-program

1. Online learning: The platform displays excellent Xue Tao paper works from ancient to modern times, introduces inheritance techniques, provides popular science videos, and offers real-time interaction with virtual tutors, strengthening users awareness of heritage value. Figure 7 illustrates the online learning area for heritage education.

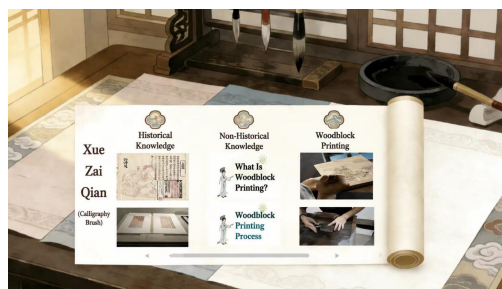


Figure 7 Online Learning Area

2. Point mall: The platform designs an online quiz module. Users accumulate points by answering questions about intangible cultural heritage and historical knowledge, which can be exchanged for mall gifts, improving learning interest and participation.

3. Design workshop: VR technology supports users in online DIY design, allowing them to customize board materials, patterns, techniques, and colors, realize online experience of offline craft, and promote O2O model transformation. Figure 8 shows the online cloud viewing design process used in the design workshop.

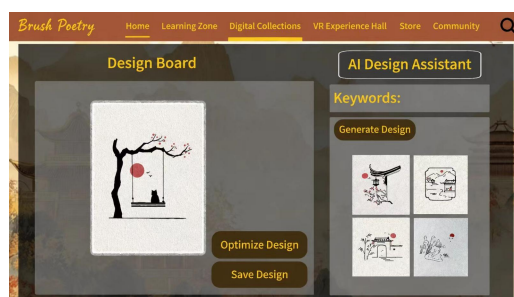


Figure 8 Online Cloud Viewing Design Process

4. Digital relic library and panoramic Xue Tao paper engraving: Through high-definition images and 360-degree views, the platform displays the details of Xue Tao paper engravings. Some functions reserve VR access interfaces, laying a foundation for immersive experience. Figure 9 presents the real-scene VR simulation for immersive cultural experience.

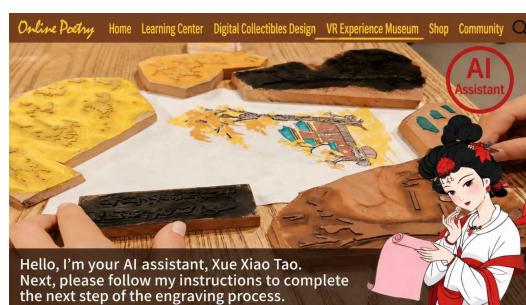


Figure 9 Real-scene VR Simulation

5. Exclusive customization: The platform sells established engraving products. Users can pay 50% of the production cost to transform DIY works into physical purchases, building a closed loop between virtual creation and real consumption.

4.2.2 Promotion of the overall platform architecture

1. Social platform matrix: Official accounts have been established on mainstream platforms such as Xiaohongshu, Douyin, and Bilibili to release phased project achievements, craft short videos, and cultural and creative products.

2. Interactive activity planning: Online knowledge quiz competitions, intangible cultural heritage knowledge challenges, DIY work evaluations, and other activities are planned. Users obtain points, exchange gifts, or unlock virtual rights by participating, such as hidden plotlines for communication between Xue Tao and other poets. Topic challenges on Xue Tao paper creative design are launched to encourage user-generated content creation and expand communication influence.

Figure 10 presents the interactive activity planning for user participation and content creation.

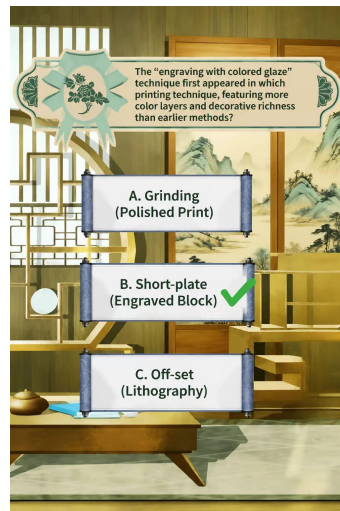


Figure 10 Interactive Activity Planning

4.2.3 Offline scene implementation

1. Cooperation with the DIY workshop Xizuo Garden: The project sets up craft exhibitions, on-site production demonstrations, and DIY experience areas to attract participation and improve public contact through handmade experience and product sales.
2. Cooperative promotion: In cooperation with specialty restaurants, Xue Tao paper elements are integrated into decorations, such as paper cups, packaging boxes, and other products, using commercial scene traffic to expand the influence of intangible cultural heritage.

Figure 11 illustrates the concept map for restaurant cooperation and commercial scene promotion.



Figure 11 Concept Map for Restaurant Cooperation

Cooperation is also established with campus media and student organizations to connect with campus cultural activities. Initial cooperation intentions have been reached with intangible cultural heritage inheritors and craftspeople, reserving resources for subsequent offline workshops and course development.

Figure 12 shows the campus-entry scene for Xue Tao paper activity development.



Figure 12 Xue Tao Paper Enters Campus

5 CONCLUSION

This study develops an economic value conversion path for Xue Tao paper woodblock watermarking through NFT digital collectibles, blockchain-based ownership confirmation, immersive consumption, customized product design, O2O service linkage, and big-data operation. The technical design connects cultural content with asset confirmation, digital collection display, personalized creation, online reservation, offline workshop participation, and user behavior analysis, forming a platform-oriented intangible heritage economy model. Survey evidence shows that public cognition of the craft is still limited, but technology-enabled heritage experiences, NFT digital collections, customized products, and immersive consumption scenes have visible market acceptance, especially among younger users. The achieved results include online and offline survey accumulation, mini-program function development, platform architecture construction, online learning resources, point mall design, VR-based design workshop, digital relic display, exclusive customization, social media promotion, activity planning, and offline cooperation resources. The current limitation is that digital collectible pricing, long-term transaction activity, user retention, technical stability, and sustainable revenue conversion still require wider market verification. Future work can deepen AI-assisted design, improve NFT traceability and rights confirmation, expand campus and workshop cooperation, and use continuous user data to refine product pricing, consumer segmentation, digital asset operation, and commercial transformation efficiency.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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