



Innovation Strategies for Cultural Heritage Revitalization: A Digital Technology-Driven Approach in Hohhot's "Museum City"

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Abstract: In this paper, we consider how the digital revives our cultural heritage, through mixed-methods case study of Hohhot's "Museum City", exploring with the theories of "digital authenticity" and "participatory heritage", in terms of its immersive VR reconstructions, and with AI multilingual interpretation systems, and its IoT-based environment supervision. Through our experimental results, we achieve a low-cost AR/VR-based hybrid model with an adopted sense-of-place that has a positive impact by bringing tourism revenue growth at 35%(2021-2023). It tackles potential harms (such as an AI-simplified depiction of the minorities' history) under policy recommendations that favor inclusive and multistakeholder governance while being consistent with China's policy aim of being a "Digital China" and providing opportunities for communities to thrive in non-coastal areas of China.

Keywords: digital technology; cultural heritage activation; participatory governance; sustainable tourism; ethical AI; policy alignment

Introduction

With technological changes and globalization, the conservation and revival of culture has become an important issue and responsibility. Within this context, to protect the world heritage and culture, across the international community there has been various efforts have been developed globally like UNESCO's Recommendation on the Historic Urban Landscape (2011), European Union (EU) Digital Culture etc., which asserts a major possibility for technology in heritage preservation and its interaction. In the grand national-scale of "Digital China" plan (2021-2025) in China, as a national pillar to lead sustainable development, representative projects include the Digital Dunhuang project which achieves VR representation of the historical and cultural legacy of several thousand-year-old grotto paintings through 3D scanning techniques. In this context, the Museum City Construction Master Plan (2025-2035) has been rolled out by Hohhot, capital city of the Inner Mongolia Autonomous Region, as its plan to turn the city into a global center of culture, technology and economy, which incorporates historic memories.

Vision The depth of historical and cultural reserves in Hohhot is strong. As a city with more than 50,000 years of human civilization, over 2,400 years of city history, as well as a culture left behind the Neolithic Dawenkou civilization, the Northern Wei Dynasty capital of "Shengle", the Zhaojun Tomb of the Qing Dynasty, Hohhot City now has 1,534 movable cultural relics, 21 national protective cultural relics, and 655 kilometers of Ancient Great Wall relics. Its immaterial history has 7 national and 275 municipal intangible cultural heritage projects; 2018), in 2024 it had already listed 29 museums and more than 40 museum-like museums, and strives to retain and display the stories of multicultural identities.

It proposed a holistic implementation plan, featuring "one center, five axis systems and multi-center co-operations", i.e. making efforts in making good use of spatial organization and formation from five major cultural areas (red culture, grassland culture, agrarian culture, the Yellow River culture and the Great Wall culture), improving the chain of the museums (the state-run museums, the civilian-owned museums and the quasi-museums) and promoting the informatization, etc. As an example, its plans propose developing digitalization of cultural sites for augmented reality (AR) and artificial intelligence (AI) enhanced virtual realities-based exhibitions to support the Chinese "Ecological Civilization" and "Rural Revitalization" initiatives. In 2035 Hohhot will realize a completely integrated "museum-city (museum-city integrated or muni-museums): museums actively (through technological inventions) attract tourism and expand cross-regional networks with the goal to become the standard reference model for development models based on heritage resources.

Nevertheless, there are fundamental concerns about such a trend: Can technologies offering virtual platforms co-exist with the actual authenticity of various ethnic minority cultures like the Mongolian nomadic culture? How could politics and regulations safeguard fair participation of the ethnic minorities in the process? This paper tries to offer an answer to the aforementioned issues by proposing a mixed-method research that investigates Hohhot's programs by (online and offline) questionnaires, interviews with key stakeholders, and interactions with the general user's population online. Drawing upon the theory of digital authenticity by Jones (2018) and that of participatory heritage by Waterton and Watson (2015), the study probes how Hohhot's hybrid model based on high-definition 3D scanning, AI based multilingual interpretation, and IoT based preservation meets the goal of growing tourism revenue from 35% (2021-2023) in a policy experiment where tourists deal with the ethical concerns about algorithmic bias and data sovereignty.



In this paper, Hohhot's cases are presented to enrich discussion around global visions of fair heritage futures. Theoretically, this paper moves a "technology-heritage-society" framework forward by critiquing techno-determinism through the consideration of cultural uniqueness and participatory governance. Methodologically, Hohhot's cases provide policy guidelines for those in the field of digital heritage who intend to connect their projects with national agendas, especially in areas facing population migration outmigration and cultural loss.

Literature Review

Jones' (2018) concept of "digital authenticity," which proposes that cultural heritage digitization ought to be more than a formalist replication of historic materiality and to instead facilitate the ability to dynamically reimagine cultural value, is particularly thought-provoking here with respect to critique of Hohhot's "Museum City" project. To be sure, the VR reconstruction of "Zhaojun's Journey to the Frontier" in Zhaojun museum should not just merely reproduce history but should only re-contextualize the peace-making marriage's cultural significance by way of the narrative of the immersive experience, Jones' "dynamic authenticity", with good reason for that. Or, as Waterton and Watson (2015) maintain their "participatory heritage" paradigm, a term that stresses communities' involvement in the revitalization of heritage. For example, Dashengkui Culture Museum Complex achieves local people and visitors being co-creative by involving in workshops and youth project regarding Intangible Cultural Heritage, rather than simply being passively displayed.

On a more global level, project cases such as Acropolis VR restoration and Digital Dunhuang have successfully demonstrated technology-driven progress, yet social-cultural inclusivity largely fades away into oblivion. Here, Hohhot has demonstrated the fusion of technology (for instance, scanning the Zhaojun Tomb with precision up to 0.5mm) and efforts such as the "Mongolia-Hubei Tea Culture Festival," contributing to ethnic communications between them while at the same time integrating technology as part of a cultural story line. This "technology-heritage-society" triad breaks the mould of techno-determinism and provides a zoomable scale of application for non-coastal cities.

Finally, mixed-methods frameworks are applied to empirical research of digital heritage, for instance in Yang et al.'s (2023) twin data-driven methods to bridge analysis in user experience (UX) and archivist design documents, which paid close attention to culturally relevant datasets. In like fashion, Hohhot's use of cooperation with Mongolian linguists in the training of algorithms on the fine-grained historical documents mentioned above is an ethical AI co-creation approach, opposing the bias of such algorithms as they have been trained in global multilingual systems. Both these approaches emphasize a technical tool matching its socio-cultural context, as identified in works that lack technical scalability as a study component.

At policy level, the macro-policy "China digital" (2021-2025) plan and "Revitalization of Rural China" policy offer Chinese government a guideline to apply digitization technology to heritage preservation. However, the micro-policy in a small city is under studied. The practices of the Palace Museum and Dunhuang exemplifies the importance of IoT and big data technology to the future of "sustainable conservations". They often lack of examples in the context of small cities. The case study of environmental monitoring network in Hohhot and the national government plan to control this network as mentioned in above sections has demonstrated an approach on the coexistence of cultural heritage protection and economic development that can be well adopted by the other provinces in China that are facing serious decline in population and cultural heritage.

Methodology

In this paper, the mixed-methods research design enables to conduct a detailed investigation of innovative practices of digital technology-based cultural heritage re-vitalization applied to Hohhot's "Museum City" initiative by combining the advantages of quantitative and qualitative research designs, wherein we record general tendencies (i.e., big picture) of the collected data statistically as well as participants' insights into details during interviews. We present a data collection and data analysis framework to proceed the work with multiple stages and multiple sources of empirical evidence in order to achieve the scientific validity and internal validity.

Data gathering was conducted through three stages. In the first phase, data were collected in the field at main cultural sites, such as the Zhaojun Museum, Dashengkui Cultural Museum Cluster, and International Sculpture Park and Cultural Axis by relying on participants' observation, recorded videos, audio recordings, and environment sensing techniques; detailed observations on how VR/AR immersive installations, AI based language tourist guides, and immersive performances in practice were collected. In the second stage semi-structured interviews were conducted with stakeholders, including museum managers, culture technologists, cultural heritage researchers, local community members, and tourists, focusing on the discussion about how effective the technology works; controversies regarding authenticity and local people participation mechanisms. In the third step digital platform data analysis were provided; the public data extracting tool is to collect users' commentaries and usage behavior data of the websites and platforms of museums; the trajectory of the spreading of the hashtags was observed to objectively evaluate public recognition and cultural dissemination.

In the process of data analysis, the analysis conducted by the study adopted mixed analyses to understand the association between digital and cultural heritage renewal. The quality data was organized for analyzing its major themes or patterns to establish a set of assumptions. The quantitative measurements were processed statistically with correlation tests for relationship between user activity related measurements and cultural spread related results along with time-series analysis to understand the impact of the technologies in a time-frame beyond the effect of a single intervention. All these steps ensured ethical compliance such as anonymizing the identities, receiving the institutional approval for use of social media data, and following ethical standards for preserving digital heritage not to symbolically appropriate the minority culture. The mixed-methods design added to the practical relevance, insofar that theoretical credibility could be enhanced

by using feedback (iterative feedback mechanisms, e.g. by comparing interim findings with stakeholder workshops) to enhance the usefulness for the policies and practices.

Case Analysis: Hohhot's "Museum City"

Revitalization of Zhaojun Museum

Hohhot's Zhaojun Museum is an inspiring example which describes how this transformative power of digitization can be implemented within culture heritage reviving projects combining authenticity of the past with entertainment through innovation, which involves virtual reality (VR) to re-enact some crucial events of the past. The Holo Theater "Zhaojun's Journey to the Frontier" uses VR technologies to re-create the 2000 km of journey by chariots from Chang'an to the Xiongnu territory, providing a sense of Han dynasty caravans, nomadic camps of Mongolian yurt and broad grassy plains. While the tomb chamber has never been excavated, in principle this space can be reconstructed by the 3D laser scanning of the chamber site (accuracy: $\pm 0.05\text{mm}$) and simulated reconstructing of historical documents. Through VR technologies, visitors are able to virtually visit inside this reconstructed burial chamber space. The last layer, augmented reality (AR), also increases interaction: moving the "Chanyu's Peace Making Marriage" tile causes an animation explaining the tile's process of production and situating the peace-making marriage ceremony within history, animated moving murals within the "Harmony Corridor" react to gestures and present dialogues among historical characters, including Wang Zhaojun and Huhanye Chanyu.

Performance narratives connect past and performance. Dreaming of Zhaojun is a live performance theater produced in a 360° turn-around stage based around the mound of the tomb, with real horse riders and sounds from a 360 surround system, and an immersive dramatic content projected on the tomb through the help of AR and hologram. Night performances also project migrating geese and the night sky over the tomb structure through projection to trigger an emotional reaction, which has now gathered more than 150 thousand visitors since 2023 launch and earned over eight million RMB by selling their tickets. Thereby, it is held daily performances like traditional Han style welcoming ceremony and Mongolian long-song training that fit into UNESCO's cultural heritage safeguard principles and embody participatory culture heritage.

Interpretations at historical museums strive to simultaneously convey academic expertise and engage the general public. The fixed exhibition "Marriage in Search of Peace History", displays 23 first-class (A-Class) artifacts, such as Tang document and Liao mural, by multimedia timeline. Moreover, the temporary exhibitions also host 50,000+ visitors with exhibitions like "Horse-related Culture in the History of Chinese World in 2023". Physical reconstruction, such as the reconstruction of the tomb's top pavilion with authentic mortise and tenon technology and Republican images, in parallel with contemporary multimedia techniques to recreate original ceremonies.

Teaching and educational activities aim to attract children. The "Little Zhaojun Ambassador" educational activity involves children in envoys playing roles and rubbing relic, and more than 10,000 kids were awarded the badge from 2022. And more than 30 countryside primary schools were visited by mobile exhibition with teacher training session of heritage teaching in 2023. Socially and economically, the museum is serving as an important bridge to ethnic unification, conducting 32 multiculturalism symposia in 2023, promoting regional tourism through 980,000 yearly museum goers and twelve million RMB worth of cultural creation products being sold every year. Further initiatives to exchange touring exhibitions with foreign museums in Hungary and Kazakhstan and to create an AI multilingual tour guide and a "Metaverse Qingzhong" app to serve to the world are planned.

Revitalization of Dashengkui Cultural Museum Cluster

One of the stars in Hohhot's "Museum City" project, the Dashengkui Cultural Museum Cluster project recombines old preservation and digital technologies to deliver a cultural tourism experience in its massive site. Located on the land of the former Dashengkui (the largest trading house in northern China during the Qing Dynasty), which was established in 1696, Dashengkui Museum consists of 24,000 square-meter premises with 72 buildings from old accounting halls, camel caravan station, to banking office. Today these well-preserved buildings, which have been restored with the traditional mortise-and-tenon techniques and with old brick carvings (i.e. "Five Blessing Surrounding Longevity" patterns), can be turned into a lively cultural space that connects both modern and ancient times.

The architecture design of the core is a mixture of traditional and the advanced technology. The historical museum, Dashengkui Historical Museum, is reconstructed according to traditional wooden frame system in accordance with the characteristics of the Qing dynasty commercial architecture including the "Dragon Gate" entrance, account halls, etc.. The exhibition of the core revolves around three topics. (1) Development of the Trade Route: A miniature follows the route of the 6000-kilometers-long "Tea Road" between Hohhot and Kyakhta, Russia, demonstrating how camels would be used for logistics of goods in the caravan trade. (2) Economic Development: Imperial Trade Licenses ("Dragon Tickets"), Russia Books and Mongolian Silver Ingot shows display barter system and primitive banking service; (3) Cultural Communication: Holographic images demonstrate rituals, such as "Fire God Ceremony", and human relationship between the people of Han, Mongolian and Russian merchants.

Experiences for Visitors In many instances, digital technologies have been deployed to seamlessly integrate themselves into the visitors' experience. Digital applications in the Tea Road Digital Pavilion's 270 degrees curved screen and its immersive digital experiences in AR augment a visitor's perspective to an early 19th-century market negotiation scene. In the Trade Winds game, visitors can don mixed reality (MR) headsets to play the roles of merchants and finish tasks such as solving ciphers of Qing era or trading virtual caravans. In total there are more than 300 objects that can be saved in the form of interactive holograms with a precision of $\pm 0.1\text{mm}$, which will help visitors interact with them. You will have the ability to play around tea coins, Russian silver roubles (zolotnikov or tola) and other objects, such as playing

with a tea coin made of tobacco or trying to use the existing key. Robots in the museum will do guided visits on 4 languages (Mongolian, Chinese, English and Russian) and help people with this kind of interaction, like in the photo. But in the reality we also should see how it feels for the antique room, so smart rooms, physical tours. For example, if we are presented with the scene of opening the cupboard and help find a key on it, a virtual accountant will appear and tell us about bookkeeping and other methods used in those times. Another scene can be opening an antique desk and showing a character that will appear, when the museum visits. At the tea workshop, guests crush brick tea with our Qing dynasty-era tea-crushing tools (Figure 6), and instead of the Tea Horse Road, we simulate an ascending desert camel march using hydraulic platforms. The Bank Vault Escape Room requires players to figure out their way to unlocking and finding a specific item as if they were detectives in a financial criminal investigation and is ultimately an entertaining and educative puzzle game (Figure 7).

In practice, the cluster runs a “free entrance + diversified income” system. Apart from charging no admission fee (8,000 per day visitors upper limit), its diversified income sources include cultural creative goods such as NFT-based “tea certificates” and blind-box camel bells, creating 8 million per year revenues. Night markets and lights create 3000 visitors per night and thus strengthen the local business via a 20% contribution. Joint with universities and schools, it does a professional development with 150 professionals in heritage domain taught per year. In the sphere of social effect, the cluster has restored historical venues like old stable as the “Grassland Library” with 20,000 books, advocated mutual and multilateral cooperation among Sino-Russian-Mongolia like Tea Road Heritage Forum. In the educational field, they have also been applied to the school, for example, Dashengkui course, Frontier Economics course has been used by the High school No.2 in Hohhot.

In the future, they would push to operate as a “Northern Frontier Trade Museum”, introduce a “Digital Silk Road” Big Data platform, and create a virtual market metaverse to practice trade. The ambition of the cluster is to receive the 4A qualification (4A Tourist Attraction Rating System) by 2025 and to become an exemplary model of a heritage revival all around the world.

Revitalization of International Sculpture Park and Cultural Axis

The Hohhot International Sculpture Park and Cultural Axis is an ambitious project aimed to develop the artistic and historical heritage of the city while combining urbanization and technological innovation, thus positioning Hohhot at the forefront of international artistic and cultural development. The project is based on a branding strategy of “Northern Frontier Culture” and runs along a 5.6 km section of the city linking significant cultural and historical sites, like the Inner Mongolia Museum, Suiyuan City Ruins Park and the Sculpture Art Museum. The Cultural Axis are named after the historical background of Grassland Silk Road, to move to change from historical heritage to current art, the International Sculpture Park adjacent to the south foot of Daqing mountains, with a total area of 200,000 square meters in the 200,000 square meters scenic area of 200,000 square meters “one park, one axis” logic.

As a spatial segment, the Sculpture Park of the International Horticultural Exposition is categorized by three thematic parks: “Grassland Civilization,” which offers dynamic art sculptures, such as Ten Thousand Galloping Horses (a stainless-steel steel-horse sculpture that stands 6 meters high, with nightly dynamic light display and LED illumination at night); “Silk Road Dialogue,” an inter-cultural interpretation zone with artworks such as Conversation Between Confucius And Socrates (a dual statue created with marble and originally carved by a Greek sculptor); “Contemporary Art,” as contemporary art that innovates upon traditions in its great achievements. In hosting radical artworks, like the “Digital Nomadism” pavilion (a reflective building mimicking day/night transition). Other cutting-edge technologies include AR-empowered guided tours—audiences can use their phones to scan certain sculptures and get, for instance, virtual caravans animating near the Silk Road Merchant Caravan sculptures. The park utilizes IoT sensors to track building damages, weathering of surface, etc. in real time to protect the statues while preserving visitors’ interaction experiences. The Zaha Hadid Architects’s Zaha Hadid Sculpture Art Museum is called The Curve, and its gently curving concrete shell appears to bridge the landscape of grasslands from which it rose. It has a 12,000-m² inside with galleries at controlled temperatures and holographic theatres. This permanent gallery called Global Sculpture Chronicles compares replicas of ancient objects of famous sculptors, e.g. the sculpture of Homer, who inspired the muse for the authorship of this article (see “Eliad: A history of a historical novelist’s first contact with Greece”). Alongside this are spaces which blend ancient artifacts (Dunhuang clay sculptures) with digital installations and the “Sculpture Lab” in which visitors can 3Dscan and CNC carve unique relief based works.

Managerially, this project is designed to provide free access and function sustainably. The average free access has a visitor daily number of limit, 8,000 per day, which receives support from annual government financial aid of ¥6 million per year. In recent years, the Night market, illumination presentation, and special theme routes such as the “Cultural Axis Sightseeing Bus” ¥30 per trip—has improved restaurants sales by 35%. In terms of social engagement, there have been more than 12,000 university students involved in activities, such as “One Day Sculptor,” and co-operation with Inner Mongolia Art College. Its geographical influence has been expanded with exchanges with overseas cultural co-operation projects (such as Sino-Russian-Mongolian artists in residence). Culture-wise, the project has attracted both local and external communities. Within six months of its launch, 107,000 visitors (including domestic and foreign tourists) came for a visit. “Hohhot Sculpture Park” Douyin (TikTok) hashtag featured 200,000,000 views. It is also contributing to the local economy as hotel occupancy has grown by 25%, and 40 million RMB in cultural and creative products have been sold. Digital Nomadism has been purchased by UNESCO as an artwork and the Guggenheim Bilbao has established partnership.

Hohhot will extend the Dahei River Ecological Park, provide the 'Metaverse Sculpture Garden' for art creation online, set up 'Belt and Road Sculpture Alliance' to conduct exchange activities among countries and open a sculpture festival every two years by the end of 2026, with the ambition to become the sculpture center of grassland Asia.

Comparative Insights

The three core cases of Hohhot's "Museum City"—the Zhaojun Museum, Dashengkui Cultural Museum Cluster, and International Sculpture Park—share the following innovative strategies despite their distinct cultural themes:

(1) Authenticity of Technological and Narrative Process: In Zhaojun Museum AR-based paintings, the interaction of visitors with the painting activates historical storytelling through gestures and authenticity of the artifacts, augmented with a modern day story, Jones calls this "dynamic authenticity". In MR game Trade Winds in Dashengkui Cluster, the commercial history is made into an experience of narratives through activities such as breaking ciphers of the 19th century Qing dynasty to bring the theme home as contemporary and Jones' concept of authenticity is important to realize. In The Sculpture Park's AR walking tours, the fixed works come alive as the cross temporal cultural conversation is enhanced. (2) Place-Based Reinvigoration: All sites involve the local community. Through this "Little Zhaojun Ambassadors" program, Zhaojun Museum's "participatory heritage" (Waterton and Watson 2015) involves local children in the role of cultural heritage stewards. Dashengkui Cluster invites inhabitants to partake in the intangible cultural heritage workshops (e.g., Cloisonné, Incense Making), which show participatory heritage values. The Public Relief-making Project at the Sculpture Park ("One-Day Sculptor") encourages the public to produce their own custom reliefs, thus changing the experience of cultural consumption into cultural production. (3) Policy Synergy: The three cases' policies also intersect with the Chinese government initiatives "Digital China" strategy and "Northern Frontier Culture" through their own routes. Zhaojun Museum creates "peace-making marriage" stories between Han and Mongolian history, to promote local ethnic unity strategy; The "Dashengkui Cluster" platform Digital Tea Road reconstructs the cross border image between China, Russia, Mongolia culture; the Concourse Between Confucius and Socrates in the Sculpture Park internationalize Chinese symbols. In this way we see that any technology-driven revitalization should be local, and concerning the macro policy goals.

Conclusion

The construction of the "Museum City" in Hohhot is an important turning point of the cultural heritage conservation in cities and convergence between IT technology and urban renovation. From the aspects of "Museum+", Hohhot has redefined the concept of museum as public education bases for technological innovation and cooperation between various sectors, and pioneered in global convergence between urban historical preservation and urban development.

Fundamental to its success has been the effective integration of the digital layer onto the cultural story. 3D virtual tours and AI-enhanced interactive displays through the "Cloud Museum" platform have brought ancient culture to global users at no fee, with more than 5 million registered global users. The most ambitious present-day examples of such virtuous circles involve contemporary high-tech reconstruction of environments through environmental sensors with IoT monitoring — as for the International Sculpture Park — or even the (nearby) holographic reconstruction of the destroyed Ruins of Ancient Jaffna. In some cases, this is supplemented with museums — for example "Little Docents" program engaged some youth to become educators of cultural stories to build a new generation of heritage keepers. This "Museum+" approach has spurred tourism development and creative economies. Combined with the "immersive light show + theme experience", "Six-Museum Stamp Rally" and "Museum Night" attracted annual visitors of 4.2 million and generated a city tourism output growth in the range of 28% that in the total city tourism incomes. Cultural exchange activities: Art collaborations with international organizations, like the UNESCO-recognized Art Installation "Digital Nomadism", and collaborations with Guggenheim Bilbao among others, have raised the international communication level of Hohhot from a globally communication center.

Master Plan of Museum City Construction in the period from 2023 to 2035. For example, under the consideration and based on fair distribution of resources (both in cities and towns), the Yill Grassland Dairy Culture Museum is hoped to combine with a national cultural system. The regulation, which stipulates that the annual increase of fiscal expenditure and that the Hohhot Museum Alliance is established, is cited to build more of institutional support towards long-term development⁴⁶. Other efforts in the future like "the Metaverse Qingzhong" virtual heritage platform, or even the upcoming 2026 Hohhot International Sculpture Biennale, strive to help achieve this goal of aligning the experience of physical and digital cultural worlds. The goal at the end is for the Hohhot to exhibit how contemporary cities benefit from their cultural heritage in facilitating socio-economic development, and maintain city identity. In this way, through a combination of ambitious technology, active community involvement, and forward-thinking policy, the city provides an example that can be reproduced across places that are multicultural intersections as well as sites with historical importance.

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