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Digital Technology Empowers the Revitalization of Industrial Heritage and the Construction of Tourist Cognition

Chen Ren
Wuxi City Vocational College, Wuxi, Jiangsu, China

Abstract: This study takes the Wuxi China National Industrial and Commercial Museum as its focal case, systematically investigating the pathways and mechanisms through which digital technology facilitates the revitalization of industrial heritage, grounded in constructivist learning theory and digital narrative theory. The core innovation lies in the proposition and implementation of a "three-dimensional integration model," which encompasses the following: activating spatial carriers through a synthesis of "historic architecture and emerging technologies" via holographic projection, augmented reality (AR) interaction, and other modalities to imbue historical structures with contemporary vitality; reconstructing experiential logic by merging "time-honored enterprises with novel scenarios," employing immersive recreations of the Maoxin Flour Mill's production processes and the entrepreneurial trajectory of the Rong family to shift industrial heritage from static display to dynamic engagement; and broadening the dimensions of dissemination through a fusion of "Republican-era aesthetics and youth-oriented expression," utilizing narrative strategies resonant with younger demographics to convey the spirit of national industry and commerce alongside the cultural legacy of the Grand Canal. This model effectively transcends the constraints inherent in conventional museum exhibitions, facilitating a pivotal transition for visitors from passive observation to active participation and cognitive construction. It thereby repositions industrial heritage from mere "artifact exhibition" towards "immersive storytelling," simultaneously deepening the efficacy of cultural transmission while augmenting touristic appeal and communicative reach, offering a replicable and scalable paradigm for the digital preservation of industrial heritage and the integrated development of culture and tourism nationwide.

Keywords: Digital Technology; Industrial Heritage Revitalization; Constructivist Learning Theory; National Industrial and Commercial Museum

1. Introduction

Against the backdrop of deep integration between urban renewal and the digital economy, industrial heritage has evolved from being considered "idle industrial remnants" to a distinctive resource possessing both cultural capital and economic development potential. Its preservation and revitalization constitute a critical nexus linking the continuity of urban cultural identity with industrial upgrading [1]. As tangible embodiments of industrial civilization, industrial heritage carries technological memory, industrial ethos, and regional cultural DNA. However, the conventional "static exhibition" paradigm inadequately captures their latent value, resulting in tangible challenges such as fragmented cultural dissemination and superficial tourist interpretation. Within this context, digital transformation has emerged as a pivotal strategy to address the "imbalance between preservation and utilization" inherent in industrial heritage. The innovative application of technologies such as holographic projection, AR interaction, and immersive environments [2] is catalyzing a fundamental shift of industrial heritage from "artifact display" towards "cultural experience," fundamentally reshaping the interactive framework through which visitors engage in a dialogue with history.

Leveraging the transportation advantages of the Beijing-Hangzhou Grand Canal and a deeply ingrained cultural tradition valuing both industry and commerce, Wuxi served as a cradle for modern Chinese national industry and commerce, earning its reputation as the "birthplace of national industrialists." Figures like Rong Zongjing and Rong Desheng, representing the

Wuxi merchant cohort, established modern enterprises such as the Maoxin Flour Mill and textile mills, thereby constructing an industrial system anchored by flour milling, cotton spinning, and silk reeling, which inscribed a saga of industrial salvation. As the principal repository of this cultural memory, the Wuxi China National Industrial and Commercial Museum's revitalization efforts are not only paramount for perpetuating the Grand Canal's cultural narrative and the spirit of national industry and commerce but also hold exemplary significance for analogous industrial heritage preservation initiatives. Nevertheless, overcoming the limitations of traditional museological presentation — rendering the historical landscape of Republican-era industry and commerce and the entrepreneurial journeys of national industrialists tangible and immersive, thereby transitioning visitors from passive observation to active cognitive engagement — remains a central challenge for its high-quality development.

Constructivist learning theory posits that cognition constitutes an active process of meaning-making, constructed by the subject through interaction and experience [3]. Concurrently, digital narrative theory provides methodological underpinnings for the dynamic dissemination of historical and cultural content [4]. Accordingly, this study adopts the Wuxi China National Industrial and Commercial Museum as its research object, focusing on the application pathways and operational mechanisms of digital technology in empowering industrial heritage revitalization, with particular emphasis on elucidating the spatiotemporal reconstruction logic embedded within the three-dimensional integration model. Employing field observation and content analysis methodologies, the research systematically examines the museum's digital narrative praxis, delineating the underlying "technology-narrative-cognition-identity" transmission mechanism [5]. It further analyzes the processes of historical cognition formation and emotional identity construction among visitors within immersive experiential contexts, subsequently proposing optimization strategies. The objective is to furnish theoretical insights and practical references for the digital transformation and integrated cultural-tourism development of similar industrial heritage museums in China.

2. Theoretical Foundations and Literature Review

2.1 Constructivist Learning Theory

Constructivist learning theory maintains that learning is not the passive assimilation of information but an active process of knowledge construction wherein individuals select, integrate, interpret, and generate meaning from information through interaction with their environment, others, and mediating tools within specific contexts. Knowledge formation is contingent upon context, prior experience, interaction, and reflective thought, rather than upon unidirectional instruction. Within the museum tourism domain, visitors are reconceptualized not as passive recipients of information but as active agents in the cognitive process. Through behaviors such as observation, manipulation, interaction, and exploration, visitors forge connections between exhibits, narratives, and settings and their own experiential frameworks, progressively constructing comprehension, memory, and identification with historical culture. The immersive and interactive contexts engendered by digital displays offer an ideal milieu for constructivist learning, effectively facilitating visitor progression from "knowing about" history to "understanding" and "identifying with" it.

2.2 Digital Narrative Theory

Digital narrative refers to a form of immersive storytelling that utilizes digital technologies to transform traditional linear textual narratives into multi-dimensional, multi-sensory, participatory, and interactive forms [6]. By employing technologies such as holographic projection, AR/VR, interactive screens, and lighting installations, digital narrative transcends constraints of time, space, and form, enabling the "re-presentation" of historical scenes, the "reproduction" of production processes, and the "re-creation" of personal stories. This transforms the audience from passive onlookers into active participants, achieving a synthesis of narrative subject and experiential subject. For industrial heritage, digital narrative effectively addresses core challenges — namely, vanished contexts, unreproducible processes, distant historical

figures, and intangible spirits—by transforming inert machinery, architecture, and artifacts into culturally resonant narratives imbued with meaning, emotion, and spirit. This substantially enhances the heritage's legibility, perceptibility, and communicability.

2.3 Research Progress on Industrial Heritage Revitalization

Research on industrial heritage revitalization [7] exhibits a trajectory initially led by Western scholarship, subsequently gaining global momentum and domestic traction. As the birthplace of industrialization, Western nations initiated research on industrial heritage preservation in the 1970s, focusing on delineating the defining attributes of industrial remains. British industrial archaeology facilitated a paradigmatic shift in conceptualizing these sites from "derelict assets" to "cultural heritage," establishing a theoretical foundation for systematic inquiry. Cases such as the Ruhr area in Germany [8] and the High Line in New York City [9] have furnished crucial practical exemplars. The adoption of the "Nizhny Tagil Charter for the Industrial Heritage" in 2003 provided a formal definition, establishing a five-dimensional value framework and articulating core preservation principles [10], thereby promoting conceptual standardization and methodological coherence. Subsequently, Western research has concentrated on functional activation and value conversion, continuously generating diverse theoretical frameworks and practical models. In China, research on industrial heritage revitalization initially involved the introduction and adaptation of Western theories, gradually crystallizing around the core principle of "prioritizing preservation with appropriate utilization." The 2006 "Wuxi Proposal" [11] marked a significant transition from theoretical introduction towards localized practical application, steering research towards greater diversification, refinement, and analytical depth.

This study incorporates multiple rounds of on-site fieldwork at the Wuxi China National Industrial and Commercial Museum. First-hand data concerning the functional efficacy of digital installations, visitor behavioral patterns, and informal interview feedback were collected through direct experience and observation. Additionally, digital narrative materials disseminated by the museum (including online exhibitions, promotional videos, and social media content), visitor online reviews (across OTA platforms and social media), and relevant media coverage were systematically gathered. The primary analytical focus was on deconstructing the narrative logic of the digital implementations and assessing the resultant user experience, thereby generating multifaceted insights for leveraging digital technology in industrial heritage revitalization and tourist cognitive construction.

3. Limitations of Conventional Exhibition and Pathways to Digital Narrative Transformation

3.1 Overview of the Wuxi National Industrial and Commercial Museum

Constructed on the premises of the former Maoxin Flour Mill, the Wuxi National Industrial and Commercial Museum constitutes a paradigmatic case of industrial heritage adaptive reuse in Wuxi. As a material relic, it bears witness to the developmental trajectory of China's national industry and commerce, possessing outstanding historical and cultural significance. Its antecedent, the Baoxing Flour Mill, was established by the Rong family in 1902, later renamed Maoxin Flour Mill. It served as the foundational enterprise for the Rong family's industrial endeavors and occupied a pivotal position within China's modern grain processing sector. The site retains key industrial structures, including the flour milling workshop, grain silos, and an office building designed by Tong Jun in 1946, thereby preserving the spatial configuration and production ambiance characteristic of modern national industry. With an exhibition area of 7,300 square meters, the museum integrates cultural relic preservation, historical exhibition, public education, cultural experience, and cultural tourism, effectively synergizing industrial heritage conservation with cultural dissemination and touristic development, positioning it as a benchmark for industrial heritage adaptive reuse in China.

3.2 Core Limitations of Conventional Static Exhibition

3.2.1 Absence of context leading to obscured historical perception

The intrinsic value of industrial heritage is embedded within its production processes, operational logic, and attendant social contexts. Conventional static displays fail to convey

dynamic elements such as machinery in operation, workflow sequences, labor practices, and industrial-commercial interactions. Consequently, visitors encounter difficulty in intuitively grasping the authentic nature of industrial civilization, resulting in superficial historical understanding.

3.2.2 Unidirectional narrative resulting in insufficient engagement

The traditional exhibition model, primarily reliant on panels, text, and static objects, promotes a linear, unidirectional mode of information transfer. This often relegates visitors to a passive spectatorial role, characterized by limited participation and exploratory impetus. Such an approach frequently leads to cursory observation and rapid forgetting, thereby diminishing the efficacy of cultural communication and potentially inducing visitor fatigue.

3.2.3 Singular experiential format failing to accommodate youthful preferences

Generation Z visitors exhibit a pronounced preference for immersive, interactive, socially engaging, and visually compelling experiences. The conventional exhibition idiom-often perceived as formal, methodically paced, and stylistically outdated — fails to resonate with these contemporary preferences. This disconnect compromises experiential appeal, diminishing visitor engagement and hindering the potential for repeat visitation and positive word-of-mouth dissemination.

3.3 Innovative Implementation Pathways for Digital Narrative

3.3.1 Development of a multifaceted digital narrative ecosystem

Centered on the objective of "reviving the century-old industrial and commercial epic," the Wuxi China National Industrial and Commercial Museum has developed a multifaceted digital narrative ecosystem comprising "scene reconstruction + holographic projection + AR interaction + intelligent services + Republican-era commercial streets," achieving a significant breakthrough in industrial heritage revitalization. An analysis of 210 valid reviews from Douyin, Xiaohongshu, and Ctrip over the three-year period from March 2023 to March 2026 reveals that positive reviews pertaining to digital elements constituted 61.90% (130 reviews), while negative reviews accounted for 17.14% (36 reviews). Concurrent with the museum's digital advancement, the proportion of positive reviews increased from 49.09% to 66.25%, while negative reviews declined from 27.27% to 11.25%. This trajectory demonstrates significant success in utilizing digital technology to "dynamically and statically" reconstruct the developmental narrative of national industry and commerce, thereby guiding visitors towards reconstructing historical cognition and cultivating a sense of national identity.

3.3.2 Scene reconstruction enhancing visitor perception

The museum's comprehensive scene holographic restorations have markedly heightened historical immersion. The 1:1 scale realistic reconstruction of the flour milling workshop, combined with holographic projection and dynamic lighting to simulate the entire production process, effectively evokes the historical operations of the Maoxin Flour Mill during the Rong family's tenure. This format was referenced 38 times in reviews over the past three years (15 on Douyin, 14 on Xiaohongshu, 9 on Ctrip), with positive feedback emphasizing qualities such as "intuitive and easy to understand" and "well-suited for educational purposes." Furthermore, the museum employs original object displays and sculptural scene recreations to cultivate a potent atmosphere of historical immersion, thereby reinforcing visitors' experiential engagement.

3.3.3 Catering to Gen Z preferences to amplify communication impact

The Republican-era style commercial street zone, which features revitalized traditional shop facades and market scenes, aligns with the aesthetic sensibilities and cultural communication preferences of Generation Z, thereby enhancing the museum's communicative reach and appeal. Platform-specific review analysis indicates that Douyin users (65.26% positive) predominantly emphasize the photogenic qualities of the space, whereas Xiaohongshu users (69.23% positive) focus on the degree of cultural integration. This differential reception confirms the zone's adaptability to diverse audience segments, while its three-dimensional presentation format further facilitates the dissemination of the digital experience.

3.3.4 Achieving "Living Interpretation" of artifacts through intelligent interactive technologies

Through AR-enabled scanning, interactive

advertising, mission-based cards, and simulation games, the museum provides multi-dimensional artifact display and interpretation. The application of AR and intelligent interactive technologies facilitates a "living interpretation" of artifacts, transitioning visitors from static "object viewing" to dynamic "historical interpretation" in their cognitive engagement. Comparative data analysis reveals that negative reviews concerning multimedia touch screens totaled 18 (representing 50% of all negative reviews), citing issues such as device malfunction and unresponsive interfaces, thereby underscoring operational maintenance challenges. Conversely, virtual guides and audio commentary garnered 27 positive reviews (nine per platform), with "convenience" and "solo-visitor friendliness" identified as core feedback themes. Intelligent interactive technologies thus offer effective means for achieving "living interpretation" of cultural artifacts.

3.3.5 Creating multidimensional narrative spaces through multimedia systems

By integrating diverse visual materials alongside features such as the "Youthful Giants" holographic projection, process animations, and online virtual tour functionalities, the museum has constructed a multidimensional multimedia narrative space that facilitates a comprehensive, three-dimensional dissemination of the history of national industry and commerce. As a flagship feature, the immersive live-action drama "Rong Gui" received 65 positive reviews (accounting for 50% of all positive reviews; 38 on Douyin, 22 on Xiaohongshu, 5 on Ctrip), with "immersion" and "strong sense of engagement" as predominant feedback themes. Concurrently, 10 negative reviews (5 on Douyin, 3 on Xiaohongshu, 2 on Ctrip) highlighted operational issues such as insufficient performance frequency and inconvenient booking procedures, providing focal points for future optimization.

4. Mechanisms of Tourist Cognition and Emotional Construction from a Constructivist Perspective

Constructivist theory posits that cognition is not a passive reception of exogenous information but rather a dynamic process of knowledge generation wherein the cognizing subject actively constructs meaning by processing information, engaging in interactive feedback, and reconstructing meaning within specific contexts, integrating these with their prior experiences. Considering the exhibition characteristics and experiential settings of the Wuxi National Industrial and Commercial Museum, tourists' cognitive construction regarding national industrial and commercial culture proceeds through a four-stage progressive mechanism: "contextual positioning—information integrati—cognitive adjustment—meaning coherence." Each stage is interconnected and sequentially layered, collectively facilitating the deepening and systematization of tourist cognition. The museum utilizes the original Maoxin Flour Mill site as its core exhibition area, preserving intact industrial heritage elements such as the original factory structure and production equipment. These serve as the physical substrate for tourist cognitive construction, capable of activating visitors' prior experiential and knowledge frameworks while establishing an initial cognitive scaffold. Building upon this foundation, the museum provides systematic information through numerous physical exhibits, AR-enhanced scene reconstructions, and other diverse modalities, facilitating knowledge assimilation and progressive refinement of visitors' cognitive systems. Through intelligent interactive experiences and immersive engagements, cognitive dissonance is deliberately induced, prompting visitors to actively restructure their cognitive frameworks, thereby enabling a transition from superficial perception to deep, substantive understanding. This process culminates in personalized meaning construction and cognitive synthesis. Digital technology supports this cognitive construction process across multiple dimensions. By reconstructing historical contexts, it translates abstract industrial heritage culture into intuitive, perceptible experiences, resolving the challenges of cognitive abstraction inherent in traditional exhibitions. It grants visitors agency in the interpretive process, propelling the shift from passive information reception to active cognitive construction, thereby closely aligning with the core principles of constructivist learning theory.

Concurrent with cognitive construction, tourist emotional construction constitutes an equally dynamic process of deepening engagement. Mediated by the museum's spatial environment, experiential design, and information dissemination pathways, emotional construction

follows a four-stage generative mechanism: "sensory awakening-empathy arousal-interactive deepening-value sublimation." This mechanism interpenetrates and mutually reinforces the cognitive construction process, ultimately leading to tourists' emotional and value identification with national industrial and commercial culture. Elements such as the historic factory buildings and vintage production equipment evoke a potent sense of presence, triggering feelings of nostalgia and reverence, thereby fostering place attachment. Through diverse interpretive strategies, including digital narratives, the museum evokes visitor empathy towards the entrepreneurial and patriotic ethos of the pioneers of modern national industry and commerce, sparking emotional resonance and nascent value identification. Interactive formats such as participation in live-action dramas and task-oriented interactions intensify emotional engagement, deepening affective bonds with the local culture and achieving a synthesis of emotional and cognitive dimensions. This process channels visitor emotions, transforming initial feelings of nostalgia and admiration into more profound states of cultural identity, national sentiment, and awareness of heritage preservation responsibility, thereby establishing stable emotional-cognitive frameworks and value orientations. Digital technology serves as a crucial instrument in facilitating both tourist cognitive and emotional construction. It revitalizes the historical significance of industrial heritage, achieving a synergistic outcome of cultural transmission and market acceptance, positioning the National Industrial and Commercial Museum as a central urban cultural landmark and a prominent cultural tourism destination.

5. Optimization Strategies and Development Recommendations

Grounded in constructivist perspectives, informed by the museum's existing practices, and leveraging the advantages conferred by digital technology, targeted optimization strategies are proposed based on a holistic consideration of the cognitive construction process. These strategies aim to facilitate the deepening and systematization of tourist cognition. Optimization efforts can be pursued across four principal dimensions:

5.1 Precision in In-Museum Scene Design

Accounting for the heterogeneity of prior experience among diverse visitor segments-including adolescents, middle-aged and older adults, and specialized researchers-digital scene design should be optimized to incorporate hierarchical experiential content tailored to different user groups. Enhancing the alignment between experiential scenarios and visitors' pre-existing cognitive frameworks can more effectively activate relevant knowledge schemas, thereby establishing a robust foundation for subsequent cognitive construction.

5.2 Enhancing the Systemic Nature of Intelligent Interactive Information

Focusing on the core requirements of tourist cognitive construction, exploratory interactive tasks should be designed, such as industrial production technology puzzles and simulations of entrepreneurial decision-making pathways. Such tasks encourage active visitor participation in discovery processes, enabling them to identify and address cognitive discrepancies and restructure their understanding. This facilitates a transition from surface-level comprehension of industrial heritage to deeper, more essential insights, aiding visitors in effectively integrating new information with existing knowledge and progressively refining their cognitive frameworks. This approach fully leverages the potential of digital technology to support tourist cognitive construction.

5.3 Promoting Synergistic Empowerment of Cognition and Emotion

Leveraging ongoing technological advancements [12], emerging technologies such as virtual reality (VR) and the metaverse should be explored to diversify exhibition and experiential formats. Enhancing the immersion and interactivity of digital scenarios can facilitate a more dynamic "living" revitalization of industrial heritage, strengthening visitors' sense of presence and consolidating the foundation for emotional engagement. Furthermore, the spiritual significance embodied by key historical figures should be explored through formats such as digital narrative micro-documentaries and digital dramatizations, triggering visitor empathy and fostering cultural identity. Achieving bidirectional synergy between cognitive and emotional processes can facilitate a mutually reinforcing enhancement of digital technological

application and the authentic value of industrial heritage, thereby supporting the living transmission of heritage culture.

5.4 Establishing Long-Term Mechanisms for Emotional Sublimation

Digital platforms should be leveraged to establish cultural communication ecosystems [13] that extend visitor engagement beyond the physical site. Through online exhibitions, cultural communities, and other digital channels, visitors can maintain ongoing engagement with the narratives of national industrial and commercial culture, deepening affective identification and shaping stable emotional-cognitive frameworks and value orientations. This approach encourages the public to utilize the museum as a platform for the organic integration of emotional engagement and cultural heritage, providing endogenous impetus for the sustained revitalization of industrial heritage.

6. Conclusion

Against the strategic backdrop of constructing a Digital China and a culturally powerful nation, the digital preservation, adaptive reuse, and enhanced public understanding of historical and cultural heritage constitute critical measures for strengthening national cultural soft power and fostering the creative transformation and innovative development of China's outstanding traditional culture. Guided by constructivist theory, this study examines the digital implementation at the Wuxi China National Industrial and Commercial Museum. The findings suggest that the iterative optimization of exhibition content and experiential formats through digital technology can effectively activate the historical significance and cultural connotations of industrial heritage, establish channels for cognitive and emotional connection between the public and the history of national industry and commerce, and facilitate the complete trajectory of visitor experience from initial perception through deep understanding to cognitive restructuring. As advanced technologies such as artificial intelligence and digital twins continue to evolve, the application scenarios and practical boundaries of industrial heritage digitization will expand correspondingly, facilitating deeper integration of industrial heritage into public life. This trajectory promises a mutually beneficial outcome of sustainable heritage preservation and enhanced public understanding, thereby contributing substantively to the robust advancement of cultural powerhouse construction.

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