

Research on Digital Exhibition Design of China Industrial Design Museum

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Abstract: Under the strategic background of digital transformation, digital exhibition has become a vital approach for design museums to strengthen the efficiency of cultural communication. Taking China Industrial Design Museum as the research subject, this paper focuses on its prominent deficiencies in current digital display, including inadequate digitalization of collections, insufficient interactive experience and outdated audio-visual facilities. Integrating interdisciplinary theories such as environmental psychology and immersion theory, this study conducts qualitative evaluation on the current situation of museum digital display through field investigation and statistical analysis. It identifies areas of relatively low visitor satisfaction concerning digital collection presentation, human-machine interaction and experiential attraction. Correspondingly, proposes corresponding optimization strategies from four dimensions: interactive exhibition arrangement, human-oriented spatial environment, intelligent digital technology and comprehensive supporting facilities. Specific measures cover immersive scene restoration, digital twin collection database construction, cloud museum development and educational space expansion. The research conclusions can may provide practical reference for the digital upgrading of China Industrial Design Museum, as well as theoretical foundation and practical reference for the construction and renewal of similar design museums.

Keywords: design museum; digital exhibition; optimal design

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1. Introduction

1.1 Research Background

Since China issued the cloud migration, data application and intelligent empowerment initiative within the 14th Five-Year Plan in 2021, digital

empowerment has evolved into a fundamental driving force promoting industrial transformation across diverse sectors (Gao, P., 2022). Such a developmental trend is particularly evident in the museum industry, which is currently undergoing a profound global transition from static physical

display modes to comprehensive digital exhibition systems (Shan, J. X., 2018). As vital carriers of design cultural heritage, design museums cover multiple disciplines including product design, industrial design, graphic design, fashion design and architectural design, and inherently possess innovative advantages. In the context of the big data era, design museums are required to break traditional operational constraints and integrate digital technologies into exhibition planning, so as to effectively undertake cultural inheritance and public service responsibilities. Digital transformation is currently reshaping the overall exhibition logic and spatial presentation modes of contemporary museums (Parry, R., 2010). Scientifically constructed digital exhibition systems can not only improve the preservation efficiency and communication scope of design cultural heritage, but also create immersive visiting scenes for audiences, thereby realizing the maximum transmission of cultural connotations and social values.

Located on the eastern coast of the Yangtze River Delta, Shanghai is one of the earliest cities in China to develop creative industries and has long served as the core representative region of national industrial design development. The China Industrial Design Museum is situated within the International Industrial Design Center in Baoshan District, Shanghai. As the first specialized museum focusing on industrial design in China, it systematically presents the complete developmental trajectory of local industrial design and clearly demonstrates the practical achievements of contemporary Chinese design, especially the innovative development of modern design in Shanghai. Nevertheless, field research indicates that the museum still faces prominent deficiencies in digital exhibition construction, including insufficient digital exhibit resources, inadequate interactive experience, outdated multimedia supporting systems, and rigid and homogenized display forms. In this regard, conducting targeted post-occupancy evaluation on the current digital exhibition environment of the China Industrial

Design Museum and proposing feasible optimization strategies to improve overall visiting quality has become an urgent practical research task.

1.2 Research Significance

1.2.1 Theoretical Significance

The Outline of the 14th Five-Year Plan and the Long-Range Objectives Through the Year 2035 emphasizes the development of smart cultural tourism, encouraging museums to develop online digital experience products, construct big data platforms, and promote emerging cultural tourism services such as immersive scenarios, virtual exhibition halls, and high-definition live broadcasts. Nevertheless, design museums in China started relatively late, and relevant research on digital exhibition practices remains in the exploratory stage, lacking systematic theoretical frameworks. Based on post-occupancy evaluation theory, this study constructs a comprehensive evaluation method for digital exhibition environments and applies it to the practical analysis of design museums. The research expands the theoretical boundary of museum studies from an innovative perspective and provides new methodological ideas and practical pathways for the diversified application of post-occupancy evaluation within the museum discipline.

1.2.2 Practical Significance

First, as one of the earliest and most influential private professional design museums in China, the China Industrial Design Museum is currently undergoing critical digital transformation and confronting multiple practical challenges. This study conducts a systematic post-occupancy evaluation of the museum's existing digital exhibition systems, identifies core spatial and technical deficiencies, and proposes targeted improvement and optimization strategies. The research outcomes effectively enhance the overall visitor experience of the China Industrial Design Museum and provide practical guidance and actionable references for the digital upgrading and

spatial renewal of other similar design museums nationwide.

Second, from the perspective of user experience research and design discipline development, the evaluation findings support the formulation of human-centered digital renewal strategies for museum exhibition spaces. This research provides reliable theoretical foundations and design suggestions for the future planning, renovation, and innovative construction of digital exhibition systems in design museums. Furthermore, the optimized digital environment can effectively improve public visiting satisfaction, strengthen the cultural influence of design museums, and consolidate their professional positioning within the urban cultural ecosystem.

2. Theoretical Foundations

2.1 Conceptual Definition of the Design Museum

In museum studies and design studies, a design museum is generally understood as a specialized cultural institution that collects, preserves, studies, and exhibits design-related objects, documents, processes, and ideas.

In this study, a design museum is defined as a formal cultural institution centered on design culture, undertaking the integrated functions of collection, exhibition, academic research, public education, and cultural promotion. It focuses on design works, creative processes, design theories, and social influences of design activities. Its core characteristics are reflected in multiple dimensions. Centering on the fundamental theme of design, such museums cover interdisciplinary fields including industrial design, graphic design, fashion and costume design, and environmental design. They balance artistic appreciation and practical application, emphasizing the close correlation between design, daily life, social development, and industrial innovation. Different from traditional exhibition venues that merely highlight the aesthetic value of finished works, design museums prioritize the presentation of design procedures and the dissemination of design thinking. Meanwhile, they

emphasize practicality and public participation, encouraging audiences to perceive, understand, and participate in design activities through interactive spatial experiences.

In summary, the design museum discussed in this paper refers to a non-profit permanent cultural institution that takes design as the core theme. It integrates systematic collection preservation, professional academic research, public cultural exhibition, educational communication, and industrial innovation empowerment. It connects historical design heritage, contemporary design practice, and future design development, promoting academic exchanges and industrial coordination within the design industry. Its core values lie in inheriting design culture, popularizing professional design knowledge, stimulating creative innovation, and facilitating the in-depth integration of design resources with social development, cultural inheritance, and technological progress.

2.2 Overview of Digital Exhibition

Digital exhibition design refers to the process of converting diversified cultural information into standardized digital forms and presenting them in museum spaces (Chen, G., 2020). It not only realizes multi-dimensional visual presentation of exhibits, but also undertakes comprehensive functions of information transmission, spatial atmosphere shaping, and visitor flow organization (Li, S. D., 2017). In recent years, theoretical and practical research on digital exhibition technology has developed rapidly across the cultural heritage field. However, targeted research focusing specifically on digital exhibition optimization for design museums remains insufficient and relatively fragmented. Therefore, this study systematically sorts out the basic connotation and theoretical framework of museum exhibition design. Combined with the unique disciplinary attributes, functional positioning, and audience characteristics of professional design museums, the research conclusions can provide theoretical reference and practical guidance for the digital transformation and

spatial exhibition upgrading of similar design museums.

2.2.1 Definition of Digital Exhibition

1) Digitalization

The concept of digitalization originates from the Latin word “digitus”, which originally means finger. With the continuous popularization and iterative upgrading of digital information technology, digitalization has become an essential technical foundation and core driving force for industrial innovation and social operation. It has profoundly changed people’s daily lifestyles, behavioral habits, and information acquisition modes, bringing comprehensive structural changes to social production and daily consumption. Essentially, digitalization relies on computer technology and network data processing technology, providing fundamental technical support for the networking, virtualization, and intelligent development of cultural information resources.

2) Traditional Exhibition Design

Traditional museum exhibition is dominated by static physical display of tangible cultural relics and design objects (Wang, H. J., 2018). Physical exhibit arrangement has long been the most direct and mainstream display method in conventional museum operation. Design works inherently integrate artistic aesthetics and practical functional attributes (Yin, D. B., 2019). Nevertheless, most traditional museum exhibition spaces arrange exhibits simply in chronological order (Su, D. H., 2015). Such single static exhibition mode presents obvious limitations. It focuses excessively on one-way cultural knowledge indoctrination, ignores visitors’ emotional experience and interactive demands, and fails to fully release the cultural value and connotation of design exhibits.

3) Digital Exhibition

Digital exhibition is a comprehensive innovation model formed by the organic integration of digital technology system and traditional museum exhibition design system. On this basis, this study defines digital exhibition as an innovative spatial

presentation method that adopts digital information technology to digitize physical exhibits and cultural resources, and relies on intelligent electronic equipment and interactive terminal facilities to realize multi-scene, multi-dimensional, and immersive cultural display.

2.2.2 Types of Digital Display

Driven by the rapid iteration of digital information technologies, the digital display forms adopted by domestic museums have gradually shifted from rigid, single-dimensional presentation modes toward diversified and multi-scene interactive systems. In current museum practices, digital exhibition methods can be scientifically categorized into two major types: one-way information transmission and two-way human-computer interaction.

1) One-way Transmission Modes in Digital Display

Digital Projection Sand Table

A projection sand table relies on computer graphics technology to construct highly realistic three-dimensional visual models. With the assistance of professional projection equipment, virtual three-dimensional or four-dimensional data models are superimposed onto physical sand table carriers. This technology enhances the overall visual presentation effect of spatial scenes, strengthens the sense of spatial realism, and effectively optimizes the immersive perception of visitors during the viewing process.

Digital Cinema System

Digital cinema equipment includes various projection forms such as arc-screen projection, circular dome projection, folded-screen projection, and gauze-screen projection. Built with professional video playback hardware in relatively enclosed or semi-enclosed exhibition spaces, digital cinemas broadcast high-definition cultural films on customized large-size screens. Such facilities deliver immersive audio-visual shock, efficiently attract audience attention, systematically convey exhibit information and historical context, and enable visitors to comfortably engage in deep cultural perception.

Pepper's Ghost Imaging System

Based on optical imaging principles, the phantom imaging system integrates physical entity models with virtual three-dimensional ghost images. Combined with multi-angle shooting technology and human visual perception characteristics, the system realizes realistic visual integration and dynamic interaction between real objects and virtual images. Supported by three-dimensional surround sound, intelligent lighting, environmental fragrance and smoke auxiliary effects, the overall exhibition atmosphere becomes highly vivid and immersive. For instance, the cultural program National Treasure, jointly produced by CCTV and the Palace Museum, widely adopted a 360° holographic phantom imaging system. By suspending three-dimensional virtual images above physical exhibition cabinets, the program effectively displayed artifact details and historical background information in a vivid visual form.

Holographic Projection System

The holographic projection system realizes suspended three-dimensional imaging in real exhibition spaces based on beam-splitter optical principles. Through real shooting and three-dimensional digital modeling of design works or cultural relics, virtual product images are dynamically superimposed onto real exhibition environments. This method constructs a comprehensive display system combining static physical scenes and dynamic virtual images, significantly enriching the visual layering of digital exhibitions.

2) Two-way Interactive Modes in Digital Display

Touch Interactive Display

Touch interaction relies on interactive terminals such as touch screens and smart interactive desktops, combined with multi-point sensing and gesture recognition technologies. Visitors can independently browse exhibit data, historical evolution, and cultural connotations through clicking, sliding, zooming and other simple operations. This interactive mode emphasizes public participation and active exploration, transforming visitors from passive viewers into

active participants in the cultural communication process.

Somatosensory Interactive Display

Somatosensory interaction realizes real-time human-computer communication by capturing human body gestures and limb movements. Using high-precision cameras and intelligent sensors, the system converts physical behaviors into digital control signals, enabling real-time linkage between visitors and exhibition content. This form of interaction provides intuitive, natural and highly immersive visiting experiences suitable for large public exhibition spaces.

Virtual Spatial Interaction

Virtual spatial interaction relies on virtual reality (VR), augmented reality (AR), and mixed reality (MR) technologies to generate highly simulated digital environments. Such technologies can either restore real historical scenes or construct completely virtual creative spaces, providing multi-sensory feedback including vision, hearing and even tactile simulation. Typical practical cases include the VR immersive exhibition Eternal Notre-Dame, the AR interactive experience of Terracotta Army in Xi'an, and the MR architectural restoration project adopted by the Nanyue King Museum, all of which effectively improve the spatial immersion and cultural perception ability of visitors.

2.2.3 Characteristics of Digital Display

Digital technologies effectively enhance the interactivity and communication efficiency of museum exhibitions (Economou, M., 2015). In general, digital museum exhibitions present four typical characteristics, including multi-dimensional narratives beyond temporal and spatial limitations, immersive experience integrating virtual and real elements, innovative exhibition paradigms in the digital era, and audience-participatory museum construction (Liu, G. Q., 2020).

1) Multi-dimensional Narratives Breaking Temporal and Spatial Constraints

Exhibition narratives transmit cultural information through physical exhibits and diversified media carriers (Chen, L. S., 2016). Museum narrative

design systematically organizes historical, cultural and scientific content through carefully selected physical collections, innovative display media, diversified exhibition methods and supporting service facilities, so as to present professional knowledge to audiences in a logical and vivid storytelling form. This process is not limited to simple information transmission; it also serves as effective behavioral guidance, capturing visitors' attention, visualizing abstract concepts, and reorganizing scattered cultural data. In this way, audiences can naturally understand cultural connotations while enjoying the visiting process. The integration of multimedia digital devices significantly strengthens scene attraction, optimizes attention guidance in exhibition routes, and ensures continuous and layered visiting perception. Meanwhile, digital exhibitions interpret core themes from multiple perspectives and dimensions, constructing richer, more interesting and open narrative contexts. Such environments enable visitors to independently explore exhibition logic and cultural implications with higher subjective initiative.

2) Immersive Experience with Virtual-Real Integration

The introduction of digital media enables the organic combination of physical exhibits and virtual technology, constructing hybrid exhibition scenarios where real entities and digital coexist. This transformation provides audiences with enhanced sensory stimulation, immersive atmosphere, virtual scenes and personalized visiting experiences. Creating immersive perceptual environments has become a core developmental trend in contemporary digital museum design (Zhou, B., 2021). Different from traditional static exhibitions dominated by physical objects, pictures and texts, digital displays embed virtual elements into real spatial scenes seamlessly, generating highly realistic and vivid exhibition atmospheres and comprehensively improving visitor satisfaction. Compared with conventional exhibition spaces, digitally empowered environments feature stronger spatial openness. During the visiting process,

audiences not only observe physical collections, but also appreciate visual aesthetics and spiritual shock brought by virtual digital scenes.

3) Innovative Exhibition Paradigm Adapted to the Digital Era

With the arrival of the digital era, traditional physical exhibition modes can no longer fully satisfy the increasingly diverse experiential demands of modern audiences. Contemporary exhibitions are required to interpret cultural themes through physical collections while overcoming the inherent limitations of single-object display. Digital exhibition technology not only optimizes the presentation effect of physical cultural relics and enriches spatial exhibition layers, but also acts as an effective medium helping visitors intuitively understand the historical context, cultural background and emotional stories behind exhibits. Furthermore, digitalization injects continuous innovation vitality into museum operations. Multi-sensory perception, multi-dimensional presentation, interactive participation and interesting scene experience have gradually become indispensable core elements of modern museum exhibition design.

4) Museum Co-Construction Based on Audience Participation

Driven by the digital revolution, museums have gradually transformed from traditional knowledge-oriented venues into interactive cultural spaces that stimulate public exploration and creative thinking. The unique interactive advantages of digital display have promoted profound institutional changes in museum operation logic. Such interactivity enables audiences to shift from passive knowledge receivers to active participants in cultural activities (Wang, X. M., 2020), and promotes deep emotional communication between visitors and exhibits, effectively improving public engagement and visiting interest. Fundamentally, the audience's social role has been upgraded from passive recipients to co-creators of exhibition content and contributors of cultural knowledge. In-depth interactive participation strengthens visitors' sense of identity and belonging, and accelerates the

functional upgrading of museums as public education and cultural communication institutions. Under the participation and joint construction of audiences, museums successfully realize the transformation from one-way cultural output to two-way interactive communication.

In this study, these theoretical perspectives are used mainly as analytical references for evaluating the China Industrial Design Museum. Environmental psychology supports the assessment of spatial comfort, lighting, circulation, and rest nodes. Immersion theory helps explain visitors' expectations for scene reconstruction, multi-sensory experience, and interactive participation. Digital heritage conservation provides the basis for discussing digital collection archives and virtual display. Post-occupancy evaluation offers the methodological logic for linking visitor feedback with later design optimization. Therefore, the following empirical analysis is organized around exhibition experience, spatial environment, digital technology, and supporting service facilities.

3. Overview and Empirical Research on the Digital Exhibition of China Industrial Design Museum

3.1 Overview of the China Industrial Design Museum

3.1.1 Geographic Location Overview

The China Industrial Design Museum is situated within the International Industrial Design Center in Baoshan District, Shanghai. Geographically, it is bordered by Songfa Road to the north, Yixian Road to the east, and Changyi Road to the south. As the first domestic professional museum themed exclusively on industrial design, it systematically exhibits high-quality design works and innovative achievements created by outstanding designers. The museum intuitively presents the complete developmental panorama of China's industrial design industry and clearly outlines the progressive achievements of Chinese design, especially the practical development of modern design in Shanghai. The supporting facilities within the

International Industrial Design Center include the Shanghai Industrial Design Center and interdisciplinary university laboratories, forming a profound regional design cultural atmosphere. In addition, high-level educational institutions such as Fudan University and Shanghai Baoshan Vocational College are distributed in the surrounding area, creating convenient conditions for long-term academic cooperation and joint research between the museum and universities. The Shanghai Glass Museum is located on the northeast side of the site. Overall, the China Industrial Design Museum possesses superior geographical advantages and comprehensive resource conditions for integrating industrial practice with university education.

3.1.2 Significance of Museum Establishment

First, the museum enables contemporary designers to expand their research vision from simply reviewing international design history to conducting integrated comparative research on both global design history and localized Chinese industrial design history. The existing research data and practical materials of Chinese industrial design are relatively fragmented and scattered. The construction of a specialized industrial design museum effectively supplements physical research resources and improves the systematicness and integrity of theoretical research on Chinese design development.

Second, the formal operation of the China Industrial Design Museum promotes the iterative upgrading and value reconstruction of industrial design products with practical application value. The core positioning of the museum is not limited to retrospective collection and simple memory of traditional old industrial products. Instead, it focuses on exploring innovative design logic based on historical design resources, driving secondary innovative redesign of traditional industrial elements, and generating new high-value industrial design creative achievements.

Third, the museum realizes the dual-value leap from single academic research value to integrated industrial practical value. The theoretical research of

Chinese industrial design requires the mutual verification of written literature and physical cultural relics. However, the existing systematic written documents related to Chinese industrial design are relatively insufficient. Therefore, the collaborative research model combining physical design products, professional written materials and historical video archives has become an inevitable developmental direction for the construction and functional optimization of the China Industrial Design Museum.

3.1.3 Research Value of Field Investigation

The selection of the China Industrial Design Museum (Figure 1) as the core empirical case of this study is based on typical practical and theoretical rationales. Firstly, it boasts high positioning matching degree. As a first-tier professional museum focusing on the whole industrial design industry in China, it integrates multiple core functions including cultural exhibition, public education, academic research, creative incubation and design practice. Its practical exploration of digital exhibition construction has typical industrial representativeness in the field of design museums. Secondly, it has prominent practical reference value. The museum is reconstructed from abandoned old industrial factories. It not only completely retains the original historical texture and industrial site characteristics of industrial heritage, but also integrates contemporary innovative modern design concepts into the overall spatial renovation (Li, Q., 2018). The mature reconstruction experience and prominent practical spatial problems existing in the museum can provide reliable empirical reference and optimization enlightenment for other similar design museums renovated from old industrial buildings. Thirdly, it has typical regional representativeness. Located in Shanghai, a core city leading the development of China's creative and design industries and a world-class UNESCO City of Design, the museum is surrounded by a strong urban design cultural atmosphere. Local citizens have high aesthetic cognition and diversified experiential demands for design culture. Its digital

exhibition practice can truly reflect the actual developmental status, practical difficulties and future optimization demands of large-scale urban professional design museums.

In terms of collection scale and category, by the completion of the field investigation, the museum has collected more than 800 pieces of standardized design collections. These works fully cover three complete developmental stages: the handicraft era, the traditional industrial era and the modern digital era. The specific collections include classic Bauhaus industrial design products, winning works of top international design awards such as Red Dot Design Award and IF Design Award, representative excellent works of contemporary Chinese industrial design, and classic design masterpieces created by Yang Mingjie. The collection categories comprehensively cover furniture innovative design, electronic product interface design, transportation tool modeling design, new material application samples and other diversified types, forming a complete and standardized industrial design collection system. It provides solid physical resource support and reliable basic conditions for subsequent spatial investigation, empirical data research and regular public educational activities.

3.2 Display Type Analysis

3.2.1 Array Display in China Industrial Design Museum

For homogeneous industrial products of different eras, such as radios and thermos flasks from various periods, the museum adopts full-wall shelving for dense and unified array arrangement. Such intensive layout produces strong visual tension and clearly presents the iterative evolution trajectory of product forms and functional structures. Through rigorous spatial order and quantitative aggregation, array display intuitively reflects the essential characteristics of modern industrial design, including standardized manufacturing and large-scale batch production. The scale effect constructs a monumental spatial atmosphere and forms a macro narrative of industrial progress. Parallel

arrangement facilitates typological comparison, enabling visitors to rapidly recognize the evolutionary logic of similar design works within a unified visual field. Serving as a high-density visual archive, this display mode carries massive historical and technical information within limited exhibition space. Beyond pure aesthetic arrangement, array display functions as a spatial medium for recording and respecting the continuous development of industrial civilization.

3.2.2 Deconstruction Display in China Industrial Design Museum

Classic sophisticated industrial products, such as mechanical cameras and traditional typewriters, are professionally disassembled into independent structural components. These disassembled parts are presented through suspended installation or flat tiling display. The deconstructed exhibition method enables visitors to observe not only the external appearance of design works, but also the precise internal mechanical structure, modular assembly logic and engineering matching relationships. It effectively reveals that high-quality industrial design emphasizes both external aesthetic modeling and internal structural rationality.

3.3 Current Situation of Digital Exhibition in China Industrial Design Museum

3.3.1 AR and QR Code Guidance System

QR codes are placed beside key exhibits throughout the exhibition halls. By scanning the codes with mobile devices, visitors can automatically obtain real-time voice explanations, view 360-degree panoramic product details, and browse in-depth designer background stories. This lightweight digital auxiliary system improves visiting convenience and enriches multi-dimensional information interpretation without additional hardware investment.

3.3.2 Multimedia Video Installation

Multimedia video installations in the museum aim to break the limitations of static physical display and transform the exhibition space into a digital theater for interpreting industrial civilization. Multiple projection screens are arranged in key areas to continuously broadcast documentaries on industrial development and historical factory assembly line footage. Dynamic videos restore product operating principles and internal textures, bringing static physical exhibits to life. Historical footage reconstructs real social and economic contexts, injecting emotional and social dimensions into industrial relics. Meanwhile, multi-screen linkage establishes a systematic digital archive. Combined with basic interactive induction technology, the installation effectively enhances on-site perception and supplements dynamic information that static exhibits cannot convey.

3.3.3 Interactive Experience Screens

Interactive experience screens break the traditional “no touching” rule in museums and transform visitors from passive viewers into active participants. Through virtual operation simulation and interactive demonstration, visitors can directly experience the human-computer interaction logic of design products and compensate for the inability to operate physical exhibits on site. The equipment strengthens immersive perception and increases visiting interest. Meanwhile, it supports independent information retrieval, allowing audiences to selectively explore design details according to personal preferences. The interactive screens fully reflect the user-centered core concept of industrial design and promote the museum’s transformation from one-way knowledge indoctrination to two-way interactive communication.



Figure 1. Interactive electronic display screens in the museum

Source: Self-photographed by the author.

3.3.4 Questionnaire Design

Based on the constructed digital exhibition evaluation index system, this study adopts questionnaire distribution to conduct systematic post-occupancy evaluation of visitors' actual experience in the China Industrial Design Museum. The questionnaire consists of two parts. The first part collects basic demographic information, including gender, age, educational background, residential location and visiting modes. The second part adopts the semantic differential method. According to the 24 established evaluation indicators of digital exhibition, opposite adjective pairs are set to form a five-level satisfaction scale, including strongly agree, agree, neutral, disagree, and strongly disagree. The corresponding quantitative scores are defined as 2, 1, 0, -1, and -2 respectively. Statistical analysis of user satisfaction data can objectively reflect visitors' comprehensive evaluation and perceptual feedback on each spatial and digital indicator.

The 24 indicators were developed according to the main components of digital exhibition experience, including exhibition presentation, spatial environment, digital technology application, and auxiliary service facilities. These dimensions correspond to the practical characteristics of design museums, where visitors are expected not only to

view finished products, but also to understand design processes, technological mechanisms, and interactive functions. The five-level semantic differential scale was used to capture visitors' intuitive satisfaction with each indicator. In the scoring process, positive values indicate relatively satisfactory experience, 0 indicates a neutral perception, and negative values suggest that the corresponding aspect does not fully meet visitors' expectations.

3.3.4.1 Basic User Information Analysis

Located in Baoshan District, Shanghai, China Industrial Design Museum is the first specialized museum focusing on industrial design in China. A total of 250 questionnaires were distributed, and 247 valid samples were recovered, with an effective recovery rate of 98.8%. All collected data met the research standards.

Demographic statistics show that the gender ratio of respondents is balanced, with males accounting for 48% and females accounting for 52%. The age groups are divided into seven categories: under 15 years old, 15–19 years old, 20–29 years old, 30–39 years old, 40–49 years old, 50–59 years old, and over 60 years old. The research participants mainly include surrounding residents, nearby office workers, tourists and students. Among all respondents, 96% have received higher education.

Detailed demographic data are shown in the following table.

Table 1. Summary of Basic User Information of China Industrial Design Museum

Basic Information	Sub-items	Frequency	Frequency Rate (%)
Gender	Male	119	48
	Female	128	52
	Total	247	100
Age	Under 18 years old	0	0
	19-29 years old	163	66
	30-39 years old	36	15
	40-49 years old	29	12
	50-59 years old	19	7
	60 years old and above	0	0
	Total	247	100
Educational Background	Primary education	4	2
	Secondary education	6	2
	Higher education	101	41
	Postgraduate Education (Master & Doctorate)	136	55
	Total	247	100
Occupation	Student	137	55
	Enterprise staff	101	41
	Public servants	9	4
	Others	0	0
	Total	247	100
Residence	Yangtze River Delta region	97	39
	Other domestic regions	150	61
	Overseas regions	0	0
	Total	247	100

Source: Taken by the author.

It should also be noted that the respondent profile is relatively concentrated. Most participants are young visitors with higher education backgrounds, especially students and enterprise staff. This structure is consistent with the professional orientation of an industrial design museum and may reflect an important part of its actual audience. However, the findings mainly reveal the expectations of a digitally literate visitor group and should not be simply generalized to all potential museum visitors.

3.3.4.2 Analysis of Questionnaire Results of China Industrial Design Museum

Visitor experience has become a core quantitative index for evaluating the comprehensive service level of modern museums (Wang, L., 2020). Based on the post-occupancy evaluation data of China Industrial Design Museum, this section systematically

analyzes user feedback from five core dimensions, including overall evaluation results, exhibition display performance, spatial environmental experience, digital technology application and auxiliary supporting service quality.

1) The overall questionnaire data presents an obvious negative skewness distribution. Among the

24 established evaluation indicators, 22 items show negative weighted scores, accounting for 91.7% of the total dimension quantity. Only 2 indicators obtain positive comprehensive scores, merely occupying 8.3%. The statistical results objectively reflect that most visitors have low comprehensive satisfaction with the overall visiting environment, digital service level and spatial experience of the museum, and only a few basic service details meet public psychological expectations.

2) Comparative analysis of single-dimensional indicators shows that visitors give the lowest comprehensive scores to the conventional exhibition and display system. In the subsequent spatial renewal and digital renovation process, it is necessary to focus on optimizing interactive interestingness, scientific lighting layout and dynamic exhibition adjustment mechanism to improve the overall presentation effect of physical exhibits.

3) User satisfaction with digital display facilities and intelligent service systems is also generally low. Although individual positive indicators such as design heritage digital protection and integrated media information services obtain relatively favorable evaluations, most practical digital function modules fail to meet actual visiting demands. The overall satisfaction of digital technology dimension ranks the lowest among all evaluation dimensions, which should be regarded as the core optimization priority in the later renovation design.

4) The comprehensive evaluation score of auxiliary service facilities is relatively unsatisfactory. Prominent practical problems include insufficient rest and negotiation spaces, imperfect industry-university-research supporting facilities, inadequate sanitary service configuration and limited cultural and creative product exhibition areas. These practical shortcomings provide direct empirical basis and key optimization directions for the subsequent functional expansion and spatial reconstruction of the museum.

4. Spatial Optimization Design Strategies of China

Industrial Design Museum

Combined with the quantitative evaluation conclusions and practical field investigation problems obtained from the above post-occupancy evaluation, this research takes digital display empowerment as the core optimization starting point. Corresponding targeted spatial renewal strategies are proposed based on the four major evaluation dimensions, so as to effectively solve the current practical bottlenecks of insufficient digital construction, single functional coordination and poor visitor experience in the museum.

4.1 Design Objectives and Practical Significance

4.1.1 Core Design Objectives

(1) Optimize interactive exhibition and display system. Traditional static physical display modes are difficult to fully interpret the complex mechanical internal structure and innovative design thinking logic of industrial products. The optimization strategy breaks the simple stacking display of single cultural relics, introduces immersive digital scene restoration and professional deconstruction display methods, strengthens the narrative coherence of exhibition content through intelligent digital technology, and helps visitors systematically understand the iterative evolution logic from industrial batch manufacturing to innovative personalized design.

(2) Upgrade humanized spatial environment. The original industrial heritage space of the museum has unique historical and industrial texture advantages, but there are obvious deficiencies in environmental atmosphere construction and human comfort perception. The renovation scheme introduces scientific intelligent lighting design and human-centered guiding circulation planning to relieve visual fatigue of long-time visiting. Meanwhile, digital immersive scene creation and interactive experience devices are added to build two-way effective communication channels between visitors and exhibition spaces, fully mobilize public active

participation, and create a comprehensive visiting atmosphere with both profound industrial heritage texture and contemporary modern aesthetic perception.

(3) Improve intelligent digital service system. Facing the practical contradiction between limited physical exhibition space and massive industrial design historical materials, it is urgent to construct a high-standard smart design museum. AR, VR and other immersive digital technologies are adopted to restore the full-scale operation logic of large industrial mechanical equipment. A complete online digital resource archive is established to break the physical space boundary of offline exhibition halls, realizing in-depth extension of cultural information and comprehensive upgrading of interactive immersive visiting experience.

(4) Expand diversified auxiliary service functions. To enhance the sustainable operational capacity and comprehensive social influence of the museum, the single traditional sightseeing-oriented visiting mode must be broken. By adding professional design workshops, academic lecture halls and integrated cultural and creative leisure areas, the research improves popular science education, social leisure and industry exchange functions, and constructs a composite cultural ecosystem integrating exhibition, academic research, practical learning and cultural tourism experience.

4.1.2 Practical Value and Research Significance

1) Design innovation value. The overall development of design museums in China is still in the initial exploratory stage. At present, there are only four professional design museums in the Yangtze River Delta, namely China Industrial Design Museum, China National Design Museum, Yang Mingjie Design Museum and Ningbo Industrial Design Museum. As the earliest built professional industrial design museum in the region, the in-depth digital display optimization research of this project can effectively improve public visiting efficiency and perceptual experience, and promote the popularization of professional

design culture and standardized construction concept of design museums across the country.

2) Cultural inheritance value. Digital technology provides reliable technical support for the efficient protection and innovative communication of industrial design cultural heritage (Zhang, N., 2019). In the digital cultural era, the presentation forms of cultural resources are constantly innovating with social development and public cultural demands. The introduction of digital display systems into professional design museums can systematically sort out and scientifically protect precious design heritage resources, optimize user immersive experience, strengthen academic design research and cross-regional cultural communication, and provide practical support for enhancing national cultural soft power and consolidating cultural self-confidence.

3) Practical educational value. Design museums have become important offline practical teaching bases for university design majors. Many colleges and universities rely on surrounding professional design museums to carry out auxiliary teaching of design theory courses. Most visitors to design museums are design practitioners and design students. Optimizing the digital display level and interactive experience environment can not only deepen the theoretical learning effect of college students, but also lay a solid practical foundation for subsequent professional practical courses and innovative design training.

4) Social development value. As an authoritative public platform for releasing professional design trends and sorting out urban industrial cultural context, design museums undertake the important responsibility of activating urban cultural vitality and boosting regional cultural and economic development. The introduction of digital interactive display technology can visualize abstract professional design information and optimize on-site visiting perception. During the immersive visiting process, the public can systematically understand design concepts, form a good social atmosphere focusing on innovative design, and encourage all groups in society to actively

participate in design innovation and cultural creative activities.

4.2 Optimization Strategies

Based on the established post-occupancy evaluation framework and visitors' practical feedback on the China Industrial Design Museum, this section proposes targeted optimization strategies from four dimensions, including exhibition arrangement, spatial environment, digital technology application, and auxiliary service improvement, so as to solve existing spatial and experiential deficiencies. The following strategies are not intended to be implemented at the same level of urgency. Measures related to interactive display, digital interpretation, lighting improvement, circulation organization, and rest facilities should be regarded as short-term priorities, because they directly respond to the low satisfaction scores in exhibition presentation, digital technology, and service facilities. Other measures, such as cloud museum construction, NFT-based cultural and creative products, and industry-university-enterprise cooperation platforms, are more suitable as medium- and long-term development directions, depending on funding, operation capacity, and institutional cooperation conditions.

4.2.1 Experience Optimization: Constructing Interactive and Diversified Exhibition Displays

1) Enhancing immersive scenes and multi-sensory experience

The introduction of immersive scene reconstruction and multi-sensory experience design aims to break the rigid, isolated and silent viewing atmosphere of traditional exhibitions and inject vivid vitality into cold industrial relics. For a long time, most exhibits in the museum are displayed in static forms, completely separated from the original production scenarios and living contexts. Without environmental background support, mechanical industrial products often appear obscure to ordinary visitors and fail to generate effective emotional resonance. Essentially, industrial design is not merely the production of physical objects, but

a direct reflection of lifestyles and productivity characteristics in specific historical periods. Through spatial and digital renovation, the traditional one-way viewing mode can be transformed into comprehensive multi-sensory engagement. Such optimization reconstructs the emotional connection between visitors and exhibits, enabling audiences to perceive the development context of industrial civilization through vision, hearing and tactile interaction. The strategy effectively lowers the threshold of cultural understanding, visualizes abstract historical memories, and promotes the transformation of the museum from a simple collection warehouse into a more perceptible cultural space.

2) Promoting perspective display and dynamic interactive presentation

The adoption of perspective exhibition and dynamic interaction fundamentally breaks the natural limitations of industrial exhibits, in which external appearances are visible while internal structures remain hidden. The core essence of industrial design lies in sophisticated internal mechanical structures and systematic operating logic, which cannot be fully reflected through traditional static display methods. Conventional exhibition only presents external modeling features, making it difficult for visitors to appreciate internal gear transmission, circuit layout and technological craftsmanship. Such superficial display greatly reduces the popular science value and exploratory attractiveness of the museum. By applying exploded structural display, transparent superposition screens and dynamic interactive installations, complex mechanical principles can be visualized and simplified for public understanding. The design satisfies visitors' curiosity about internal operating mechanisms, especially young audiences, and transforms passive knowledge reception into active independent exploration. This measure turns static design specimens into dynamic logical processes, helping visitors deeply understand the technical heritage and craftsmanship spirit behind local manufacturing. In addition, the museum currently relies excessively on text and graphic explanations

with outdated presentation methods, resulting in limited communication efficiency. Supplementing digital media equipment such as projection systems and intelligent display screens can significantly enrich exhibition layers and improve overall narrative effectiveness.

3) Expanding in-depth digital experience based on VR and AR technology

Virtual reality technology can construct highly immersive virtual environments and realize the effective integration of physical scenes and virtual digital information (Li, M., 2021; Zhao, Z. Y., 2020). The introduction of VR and AR technologies enables the museum to break the temporal and spatial limitations of physical exhibition spaces and reshape interactive relationships between visitors and industrial heritage. Restricted by cultural relic protection regulations, audiences cannot closely touch or operate physical industrial exhibits on site, and large-scale mechanical equipment cannot demonstrate internal dynamic operating logic under static display conditions. The integration of VR and AR helps build unlimited cloud exhibition spaces and relieves the contradiction between abundant collections and limited indoor areas. With the support of digital twin technology, visitors can virtually disassemble precision instruments, simulate driving historical industrial vehicles, and perspectively observe internal core components in immersive virtual scenes. The strategy applies cutting-edge digital technologies to inherit classic industrial civilization, transforming single visual appreciation into two-way in-depth exploration. In this way, industrial historical development is no longer limited to static physical display, but becomes an intuitive, accessible and interactive digital cultural experience.



Figure 2. Comparison of the China Industrial Design Museum before and after VR/AR digital renovation

Source: Self-photographed by the author.

4) Adding temporary exhibition halls and implementing dynamic spatial adjustment mechanisms

Industrial design is a rapidly developing and continuously innovative discipline. Over-reliance on fixed permanent exhibition layouts fails to reflect cutting-edge design trends and emerging technological breakthroughs in a timely manner, gradually disconnecting museum content from current social concerns. Such rigid exhibition modes easily reduce visitors' willingness to revisit and lead to a one-time visiting phenomenon. The addition of flexible temporary exhibition spaces and dynamic adjustment mechanisms aims to break the static solidification limitations of traditional permanent displays and construct resilient exhibition spaces that keep pace with contemporary design development. By setting up multi-functional temporary exhibition areas and adopting modular, movable exhibition facilities, the museum achieves

flexible and rapid curation capabilities. This enables the regular introduction of international touring exhibitions, avant-garde design concept exhibitions, and new product launch activities, ensuring that exhibition content remains fresh and diverse. Meanwhile, the multi-purpose space can also accommodate academic forums, design competitions, and industry exchange events. This measure transforms the museum from a closed historical collection space into an open and dynamic design communication hub, continuously generating cultural and industrial value and maintaining the long-term vitality of the museum.

4.2.2 People-Oriented Principle: Constructing Reasonable and Comfortable Spatial Environment

1) Participatory design and gamified visiting circulation planning

The charm of industrial design lies not only in finished products, but also in the collision of creative thinking and the whole innovative design process. Nevertheless, traditional single-linear visiting routes easily cause visual fatigue and mental burnout. Under the conventional display-viewing mode, visitors remain in a passive viewing position and cannot fully understand designers' problem-solving logic and creative innovation process. The renovation integrates task-driven mechanisms and role-playing gamified experiences into the overall circulation system, transforming traditional exhibition areas into open co-creation spaces. Visitors are converted from passive spectators into active design participants. Through interactive puzzle solving, simulated component assembly, and immersive design decision-making experiences, audiences can intuitively perceive the complete logical process from conceptual brainstorming to final product shaping. This optimization breaks the rigid impression of traditional popular science education, embedding professional design knowledge into entertaining interactive scenarios. Each visiting experience becomes a creative practice process that enhances visitors' sense of achievement and innovative thinking. The strategy fundamentally changes the dull passive reception

mode of traditional museum visits and transforms the educational function of the museum into an enjoyable, interactive, and knowledge-oriented active exploration journey.

Restricted by the original spatial layout, the existing planar functional zoning cannot fully meet the diversified experiential and operational demands of modern museums. Therefore, reasonable expansion and integrated renovation of surrounding supporting areas are carried out. The museum is located within a comprehensive industrial park with complete supporting resources, including numerous design incubation bases and university joint laboratories. Such superior industrial and educational resources provide favorable external conditions for the diversified functional development, interdisciplinary cooperation, and long-term innovative operation of the museum.



Figure 3. Plan comparison of the exhibition area of China Industrial Design Museum before and after renovation

Source: Drawn by the author.

2) Balanced Cold and Warm Integrated Lighting Design

Industrial exhibits are mainly composed of metal, glass and composite materials, covering multiple historical periods of industrial development. The traditional single light source and excessively cold white lighting with a simplistic industrial style often make exhibits look rigid and monotonous, easily causing visual fatigue among visitors. Such rigid lighting methods fail to convey the humanistic temperature and emotional value behind design works. By introducing intelligent color temperature adjustment and zoned lighting layout, the museum realizes targeted lighting design for different exhibits. High-color-temperature cold light is adopted to highlight the tough lines and metallic texture of mechanical equipment, fully reflecting the rationality and precision of industrial manufacturing. Low-color-temperature warm light is used to wrap daily necessities and historical documents softly, evoking the warm life atmosphere and emotional memories of past eras. The dialectical balance of light and shadow constructs a rhythmic visual narrative. Visitors can shuttle between rational technological atmosphere and perceptual historical context, obtaining professional, clear, comfortable and immersive viewing experience. The design reshapes the physical texture of exhibits and the emotional temperature of the space, effectively relieving the cold and alienated atmosphere commonly seen in industrial-themed exhibition halls.

3) Coherent and Flowing Narrative Circulation

The evolution of industrial design is not scattered independent display of individual products, but a continuous developmental process driven by technological accumulation, material innovation and aesthetic iteration. Outdated and chaotic visiting circulation easily leads to temporal and spatial cognitive disorder. It is difficult for visitors to grasp the internal development context of Chinese manufacturing from imitation to independent innovation and from traditional manufacturing to intelligent manufacturing, resulting in fragmented cognition and incomplete overall understanding. Through renovation, a progressive and well-structured narrative

circulation is constructed. The museum perfectly synchronizes visitors' physical movement in space with the logical evolution of industrial design development. This measure abandons the crude exhibition mode of simple exhibit stacking and transforms the whole museum space into a readable three-dimensional historical record through systematic spatial narrative planning. In this way, visitors can clearly perceive the developmental trajectory of China's industrial design during the whole visiting journey.

4) Rhythmic Layout of Rest Nodes

The rhythmic layout of rest nodes in China Industrial Design Museum aims to alleviate the widespread museum fatigue and provide necessary breathing and thinking intervals for high-density continuous visiting activities. Industrial design exhibitions involve professional technical popularization, complex mechanical structure identification and long walking distances. High-intensity information input and continuous visual stimulation easily cause dual physical and mental exhaustion, resulting in scattered attention and impetuous emotions in the later stage of the visit. Combined with the transformation of exhibition narrative chapters and the psychological rhythm of passenger flow, scientific rest nodes are reasonably arranged to form a benign spatial rhythm of viewing, thinking, resting and continuing to visit. These nodes are not merely simple seating areas, but functional settling zones for thinking and recovery. The fully humanized layout reflects refined design care. Visitors can pause to appreciate the design wisdom behind exhibits at a steady pace, transforming intensive and tiring visiting into relaxed, elegant and comfortable cultural appreciation experience.

4.2.3 Technology Empowerment: Constructing Diversified and Intelligent Digital Exhibition System

1) Supplementing Diversified Digital Technology Exhibits

Supplementing digital technology exhibits broadens the connotation boundary of traditional industrial

design and promotes the transformation of exhibition focus from physical shape display to interactive digital experience. Traditional industrial design exhibitions are limited to physical dimensions such as mechanical structure, material craftsmanship and external modeling. In the intelligent interconnected era, core design research gradually extends to user interface design, user experience optimization and algorithm logic research. Relying solely on traditional hardware exhibits cannot fully reflect the overall development leap of Chinese manufacturing from physical processing to digital intelligent production, resulting in the lack of contemporary developmental context. By introducing intelligent wearable devices, AI interactive terminals, virtual simulation equipment and typical service design cases, the museum intuitively presents the new integration trend of hardware and digital virtual interaction. Modern industrial design is no longer limited to static physical shaping, but evolves into a dynamic systematic design containing data flow, human-computer interaction and scenario service linkage. The museum therefore acts not only as a recorder of traditional industrial history, but also as a predictor of future intelligent lifestyles.

2) Constructing Digital Twin Cultural Heritage Database

The construction of a digital twin heritage database breaks through the physical limitations of natural aging of physical collections and insufficient exhibition space, building a stable digital archive for precious industrial cultural heritage. Industrial design relics such as ancient design manuscripts, out-of-print prototypes and early mechanical equipment face irreversible risks including paper embrittlement, metal oxidation, material aging and component loss. Traditional physical preservation can only delay aging but cannot resist natural erosion. Restricted by limited exhibition area, a large number of large-scale industrial equipment are stored in warehouses for a long time, unable to exert educational and research value. With digital twin technology, micron-level high-precision 3D scanning and full-element data reconstruction are

conducted on cultural relics. The morphological features, surface textures and complex internal structures of physical exhibits are converted into permanently stored digital assets. The renovation realizes digital symbiosis protection of cultural relics, avoids cultural heritage loss caused by physical aging, and supports non-destructive virtual disassembly, restoration and in-depth academic research for researchers and the public. It lays a solid data foundation for future cloud exhibition and cross-regional academic sharing.

3) Building Intelligent Digital Operation Service System

The introduction of an intelligent digital system abandons the extensive manual operation mode and builds a real-time sensing and self-regulating digital brain for the whole museum. The intelligent system reconstructs traditional visiting experience and breaks the one-way static communication limitations of conventional exhibitions. It transforms obscure historical and cultural information into perceivable, participatory and immersive interactive content, effectively lowering the appreciation threshold, meeting the visiting needs of all-age audiences, enhancing attraction and user stickiness among young groups, and improving comprehensive museum management and service capabilities (Wu, Z. Q., 2021). The intelligent upgrading responds positively to the national cultural digital development strategy, promotes the in-depth integration of traditional industrial culture and modern digital technology, revitalizes industrial cultural relics, and realizes the creative transformation and innovative development of excellent traditional culture. The museum is upgraded from a static exhibition venue to an accessible, approachable and sustainable public cultural platform. The intelligent digital system summarizes and integrates exhibit information of different exhibition areas into a unified digital terminal. Visitors can independently search for detailed exhibit introductions according to personal preferences, greatly improving visiting autonomy and convenience. In view of the large volume of some industrial products that are inconvenient for

comprehensive observation, the digital system provides all-round three-dimensional images to realize multi-angle panoramic display.

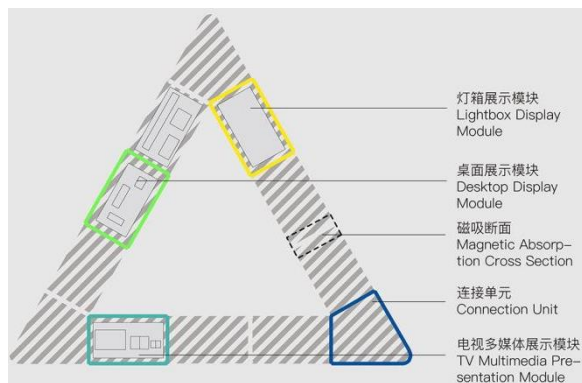


Figure 4. Rendering of the intelligent exhibition system in China Industrial Design Museum

Source: Drawn and Self-photographed by the author.

4) Development of Cloud Museum and NFT Cultural and Creative Products

The development of a cloud-based online museum and non-fungible token (NFT) digital collections aims to break the physical and geographical limitations of offline venues, reconstruct the cultural communication and operational logic of the museum, and expand the museum's online communication channels. As an important public space for displaying innovative industrial wisdom, relying solely on offline visiting and physical cultural and creative sales limits radiation scope, failing to reach global design enthusiasts and meet the digital consumption demands of Generation Z for virtual cultural assets. Traditional physical cultural and creative products lack unique scarcity

and are difficult to carry the profound historical connotation and intellectual property value of industrial design collections. The construction of a cloud museum realizes all-weather global online exhibition without time and space restrictions. Supported by blockchain and NFT technology, precious industrial design manuscripts and out-of-print prototype models can be endowed with unique digital certificates, realizing digital right confirmation and permanent digital collection of industrial cultural heritage. The strategy transforms passive viewing behavior into active cultural possession. It not only expands the audience coverage and diversified revenue channels of the museum, but also activates the sustainable circulation value of industrial design heritage in the digital era through blockchain technology.



Figure 5. Alipay NFT exclusive skin of China Industrial Design Museum

Source: China Industrial Design Museum · Official Website.

4.2.4 Comprehensive Extension and Improvement: Construction of Complete and Convenient Auxiliary Service System

1) Expansion of professional educational practical spaces

The addition of independent educational spaces breaks the traditional dilemma of emphasizing collection storage while ignoring public education, upgrading the museum from a simple historical exhibition room to a comprehensive training incubator for improving public design literacy. Industrial design is an applied discipline focusing on logical reasoning, hands-on practice and material perception. Traditional static exhibition only presents the final product appearance. Visitors can only observe the surface shape through glass cabinets but cannot deeply understand the core design thinking and complex creative process. One-way knowledge indoctrination without interactive participation makes abundant collections fail to effectively cultivate innovative thinking among young people, resulting in superficial social education effects. By adding professional design workshops, popular science classrooms and STEAM maker spaces, a complete cognitive closed loop of visiting, learning and practical creation is established. The strategy complements the practical educational function, enabling the museum to become an important second classroom outside campus. Through model assembly, structural disassembly analysis and creative design painting activities, innovative awareness is cultivated among teenagers, and high-quality talents with both aesthetic literacy and engineering practical ability are reserved for the future development of Chinese manufacturing industry.

2) Construction of integrated cultural and creative experience center

Cultural and creative development is an important way to realize the value transformation of museum cultural resources (Chen, X. H., 2021). The construction of a specialized cultural and creative center connects the last link between cultural appreciation and daily consumption, transforming

industrial design aesthetics in exhibition cabinets into accessible lifestyle products for the public. Essentially, industrial design integrates artistic aesthetics, commercial value, practical functions and material technology. If the museum only provides static ornamental display without supporting cultural and creative consumption channels, visitors cannot fully perceive the practical value of design in improving life quality, and long-term cultural communication effects cannot be formed. Single ticket revenue cannot support sustainable museum operation and academic research, resulting in the difficulty of cultural value transformation. The renovated cultural and creative area integrates product sales, new design product release and life aesthetics experience. It is not only a simple commercial space, but also a portable mobile exhibition hall that can be integrated into daily life. The strategy realizes the dual goals of museum sustainable operation relying on cultural consumption and efficient cultural output. Classic design elements with historical value are popularized among ordinary families through modern cultural and creative carriers. Meanwhile, it provides commercial transformation channels for contemporary designers and promotes the living inheritance of excellent industrial design culture.

3) Optimization of human-oriented public service facilities

The optimization of supporting service facilities fully practices the people-oriented design philosophy, extending the exhibition focus from exhibits themselves to humanistic care and building a warm and inclusive public cultural space. As a typical venue advocating the concept of design improving life, imperfect basic supporting facilities such as insufficient rest seats, inadequate storage space, lack of catering service and incomplete barrier-free facilities easily cause physical discomfort and psychological museum fatigue, shortening visiting duration and reducing overall satisfaction. The absence of humanized services contradicts the core industrial design concept of user experience priority. The renovation adds scientific rest nodes, intelligent luggage storage

systems, maternal and infant rooms and high-quality light catering service, cooperating with digital intelligent service terminals. It eliminates practical obstacles during visiting and realizes seamless comfortable spatial experience. The measures effectively prolong visiting duration, improve visitor satisfaction and revisit willingness, and practically demonstrate that excellent industrial design exists not only in exhibition cabinets, but also in every humanized service detail.

4) Building industry-university-enterprise cooperative linkage platform

Building in-depth cooperative connections with enterprises bridges the gap between historical industrial collections and contemporary industrial development. The museum is transformed from an independent cultural exhibition platform into a core hub of industrial innovation, realizing the in-depth integration of industry, education, research and exhibition. The practical vitality of industrial design originates from commercial application and mass production. Isolated museum operation disconnected from manufacturing development cannot give full play to the inspirational and guiding value of design resources. Enterprises often face difficulties in design transformation and brand upgrading, while museums possess abundant design cases and aesthetic resources lacking effective output channels, resulting in resource mismatch. The renovation builds joint innovation laboratories, new product release halls and industry exchange salons to connect classic design heritage and intelligent manufacturing future. It enables enterprises to obtain historical theoretical support and high-standard exhibition exposure, and helps museums serve the real economy, promoting the transformation from Made in China to Created in China.

5) Addition of themed catering and leisure areas

The construction of themed catering leisure areas upgrades the single visual visiting experience to multi-sensory lifestyle experience, continuing industrial design narrative through taste and spatial perception. Without supporting themed catering spaces, visitors can only watch exhibits remotely

rather than experience design in daily use. Single functional experience easily interrupts visiting routes due to physical demands and misses the opportunity to display industrial design in catering scenarios. The themed catering area integrates classic ergonomic furniture, design tableware and industrial-style atmosphere, forming a usable dynamic exhibition space. Chairs, tableware and service facilities in the area are all practical design exhibits. The area effectively relieves visiting fatigue, prolongs staying time, creates social and punch-in scenarios, and enables visitors to intuitively perceive how design aesthetics serve daily diet and life in leisure time.

5. Conclusion and Future Prospects

5.1 Research Conclusions

Taking the China Industrial Design Museum as the typical research case, this study integrates interdisciplinary theoretical foundations including environmental psychology, digital heritage conservation and immersive interaction theory. By adopting theoretical framework deduction, field on-site investigation and questionnaire quantitative analysis, this paper systematically constructs a comprehensive evaluation system for digital display effect of design museums and further proposes targeted improvement countermeasures. The major research conclusions are drawn as follows.

First, the multidimensional practical bottlenecks of current digital exhibition construction are systematically identified. Supported by field spatial measurement and statistical data of 247 valid visitor questionnaires, the research verifies that the museum suffers from comprehensive deficiencies covering exhibition, space, technology and service dimensions. In terms of exhibition presentation, the overall display mode remains relatively rigid and static, lacking interactive narrative design and immersive scene reconstruction, while the traditional multimedia playback system fails to meet contemporary visiting demands. In terms of spatial environment, the functional zoning arrangement is unreasonable, the human-oriented

spatial comfort is insufficient, and the progressive narrative logic of visiting circulation is fragmented. In terms of digital technology application, the digital reconstruction coverage of physical exhibits is relatively low, and the human-computer interactive response efficiency needs to be further improved. Only digital heritage protection and integrated media information services obtain relatively positive user feedback. In terms of auxiliary supporting services, intelligent interpretation guidance, cultural and creative commercial supporting facilities and industry-university-research cooperative platforms are obviously inadequate. The above empirical results suggests that the current digital service level cannot match the experiential expectations of modern museum audiences.

Second, the demographic characteristics and hierarchical demand preferences of core visitor groups are quantitatively summarized. The survey statistics indicate that the dominant visitors are young residents aged 19 to 29, accounting for 66% of the total samples, among which students and enterprise practitioners account for 55% and 41% respectively. Up to 96% of respondents have received formal higher education, and 61% of visitors come from non-core areas of the Yangtze River Delta. Such user groups generally possess proficient digital operation literacy, with strong willingness to participate in immersive interactive scenes and intelligent personalized services. They pursue in-depth interpretation of design logic and industrial cultural connotation behind physical exhibits, and simultaneously attach importance to spatial comfort, walking smoothness and service convenience during the whole visiting process. The research indicates the core user orientation and realistic demand basis for subsequent spatial renewal and digital optimization design.

Third, a four-dimensional collaborative closed-loop digital optimization system is constructed. Corresponding to the quantified evaluation weaknesses and actual user demands, this study puts forward systematic renovation strategies from four synergistic dimensions of exhibition

reconstruction, spatial regeneration, digital empowerment and functional supplement. At the exhibition level, the optimization measures include building full-sensory immersive scenes, adding perspective dynamic interactive displays, introducing VR and AR deep immersive experience modules, and setting up flexible temporary exhibition spaces to realize real-time iterative updating of exhibition content. At the spatial level, the renovation integrates gamified task-driven circulation, balanced dual-temperature intelligent lighting, continuous narrative visiting routes and rhythmically arranged humanized rest nodes. At the digital level, the strategies cover expanding intelligent digital exhibits, establishing high-precision digital twin heritage archives, constructing full-scene intelligent management platforms, and developing cloud online museums and NFT digital cultural and creative assets. At the service level, the scheme includes expanding practical educational maker spaces, upgrading integrated cultural and creative experience centers, optimizing barrier-free public facilities, building school-enterprise collaborative innovation platforms, and adding themed industrial-style catering leisure areas. Ultimately, a preliminary four-dimensional optimization framework featuring experience upgrading, spatial adaptation, technological empowerment and functional extension is formed.

5.2 Research Prospects

This research mainly focuses on the actual operational difficulties and digital display deficiencies of the China Industrial Design Museum, and pertinently proposes localized spatial and digital improvement strategies based on empirical data. Nevertheless, the applicability, scalability and cross-scene adaptability of the proposed optimization schemes have not been verified through comparative analysis with other types of professional design museums. In follow-up in-depth research, diverse resource endowments, spatial scales, operational positioning and industrial service attributes of different design museums

should be fully considered. On the premise of classified scenario discussion, the existing strategic framework can be dynamically adjusted, supplemented and optimized, so as to effectively enhance the practical operability and universal popularization value of the research outcomes and provide reliable theoretical references and practical paths for the high-quality digital transformation of domestic design museum clusters in the future.

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References

- Chen, G. (2020). *Research on digital exhibition and display design*. China Architecture & Building Press.
- Chen, L. S. (2016). *Theory and practice of museum exhibition curation*. Cultural Relics Press.
- Chen, X. H. (2021). Integrated development mechanism of cultural and creative industries under museum digital empowerment. *Cultural Industry Research*, 18(4), 33-34.
- Economou, M. (2015). Museums and interactive digital technology innovation. *Museum Management and Curatorship*, 30(2), 18-19.
- Gao, P. (2022). Research on the digital transformation development paths of contemporary museums. *Science, Technology and Culture*, 8(3), 14-15.
- Li, M. (2021). Practical application and scenario expansion of virtual reality technology in museum exhibitions. *Modern Information Technology*, 5(12), 27-28.
- Li, Q. (2018). Conservation strategies and adaptive reuse methods of modern industrial heritage resources. *Architectural Journal*, 59(5), 20-21.
- Li, S. D. (2017). *Fundamentals of exhibition design principles*. China Architecture & Building Press.
- Liu, G. Q. (2020). Practical research on the systematic construction of digital museum platforms. *Library Tribune*.
- Parry, R. (2010). *Museums in a digital age*. Routledge.
- Shan, J. X. (2018). *The power of museums*. SDX Joint Publishing Company.
- Su, D. H. (2015). *General introduction to museum studies*. Cultural Relics Press.
- Wang, H. J. (2018). *Basic theories of Chinese museology*. Higher Education Press.
- Wang, L. (2020). Visitor perception and behavioral experience evaluation in public museum spaces. *Tourism Tribune*, 35(8), 24-25.
- Wang, X. M. (2020). Interactive experience optimization of new media exhibition spaces. *Zhuangshi*, 33(6), 19-20.
- Wu, Z. Q. (2021). Systematic planning and intelligent construction path of smart museum clusters. *City Planning Review*, 45(7), 31-32.
- Yin, D. B. (2019). *Introduction to design studies*. Hunan Science and Technology Press.
- Zhang, N. (2019). High-precision digital preservation and innovative inheritance of cultural heritage resources. *Sciences of Conservation and Archaeology*, 41(2), 25-26.
- Zhao, Z. Y. (2020). Interface optimization and interactive logic design of augmented reality spatial applications. *Computer Engineering*, 46(9), 27-28.
- Zhou, B. (2021). Spatial design strategies of immersive exhibition scenarios in cultural museums. *Packaging Engineering*, 42(10), 19-20.

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