

Spatial Design Strategies for the China Industrial Design Museum from the Perspective of Functional Integration

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Abstract: Against the backdrop of cultural industry upgrading and urban regeneration, the single-function model of design museums can no longer meet diversified public needs. This study takes the China Industrial Design Museum as the research object, aiming to explore the spatial optimization strategy for functional integration. Based on literature review, field investigation and in-depth interviews, this study systematically analyzes the spatial layout, functional structure, operation mode and visitor experience of the museum. The results show that the museum has a professional collection system and clear positioning, but still faces prominent problems such as insufficient functional synergy, monotonous circulation design, weak interactive experience and lack of auxiliary spaces. Multiple functions are simply superimposed rather than organically integrated. To solve these problems, this study constructs three functional integration modes: collection-culture inheritance, exhibition-community service, and education-research-industry renewal. Four design principles are proposed, namely functional collaboration, spatial adaptability, experience priority and sustainable development. Furthermore, this study puts forward a phased spatial optimization scheme from the aspects of circulation reconstruction, functional zoning, material selection and exhibition system optimization. This study enriches the theoretical system of spatial design of professional design museums, and provides practical reference for functional upgrading and spatial renewal of similar museums.

Keywords: functional integration; design museum; spatial design; China industrial design museum

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1. Introduction

1.1 Research Background

Rapid social progress and rising public cultural demands have continuously driven design museums to explore new development paths (Zhang Jin, 2004). Functional integration has

emerged as a critical trend, breaking the traditional single-function exhibition-oriented pattern by organically combining exhibition, education, research, communication, and leisure to deliver diversified visitor experiences (Zhou Jie, 2012). As iconic urban cultural and creative landmarks, design museums also shoulder multiple social responsibilities, including cultural transmission, public education, industrial empowerment, and urban image enhancement (Chen Ming, 2020). Such roles require spatial functions to transcend the conventional mono-functional model and achieve synergistic integration of multiple purposes.

1.2 Research Significance

1.2.1 Theoretical Significance

First, this study enriches the theoretical system of spatial design for design museums. By deeply integrating the concept of functional integration with spatial design in design museums, it clarifies the core logic, theoretical framework, and design principles of spatial design in design museums from the perspective of functional complexity, and makes up for the lack of interdisciplinary research between current spatial design in design museums and the theory of functional complexity from a new perspective.

Second, it supplements the application theory of the concept of functional complexity in public cultural spaces. Taking the China Industrial Design Museum as a specific case, this study deeply analyzes the application paths, existing problems, and optimization directions of the concept of functional complexity in the space of design museums, and provides a theoretical reference for the application of the theory of functional complexity in similar public cultural spaces.

Third, it sorts out the classification types and spatial characteristics of design museums, constructs a suitable theoretical framework for functional complex spatial design, and enriches the connotation of classification research and spatial design theory of design museums.

1.2.2 Practical Significance

First, focusing on the China Industrial Design Museum, this study conducts an in-depth investigation into the current state of its spatial-functional integration, identifies existing problems and deficiencies, and proposes targeted optimization strategies. These strategies aim to improve its spatial layout, enhance functional synergy, and strengthen visitor experience, thereby further enabling the museum to fulfill its roles in cultural dissemination and industrial empowerment, and enhance its influence within the sector.

Second, for the contemporary design museum industry, the proposed spatial design strategies for functional integration offer applicable practical solutions for spatial design and functional upgrading of various design museums—especially private and sector-specific ones. These solutions help address developmental challenges such as single-function structures and insufficient visitor experiences, and promote high-quality development of the design museum industry.

2. Theoretical Foundations

2.1 Theories Related to Design Museums

2.1.1 Definition of the Design Museum

According to Wikipedia, a design museum centers on product, industrial, graphic, fashion, and architectural design. Most existing design museums focus primarily on applied and decorative arts, with collections dating mainly from the twentieth century onward.

In this study, a design museum is defined as an institution centered on design culture, dedicated to the collection, exhibition, research, education, and promotion of design works, processes, ideas, and impacts (Li Huizhu, 2003). Its core characteristics include: taking design as its central theme, covering industrial design, graphic design, fashion design, environmental design, and other fields; integrating artistic and practical values, emphasizing the close links between design, daily life, society, and industry (Liu Guanzhong, 2018); emphasizing the presentation of design processes and the

dissemination of design thinking rather than merely the aesthetic value of finished works; and featuring strong practicality and participation, encouraging public understanding and engagement through interactive experiences.

In summary, the design museum in this paper is a non-profit permanent cultural institution with design as its core theme. It integrates systematic collection, academic research, public exhibition, educational communication, and innovative empowerment. It focuses on diverse design works and design culture, connects history, the present, and the future, and promotes design exchange and industrial development. Its core values are to inherit design culture, popularize design knowledge, stimulate design innovation, and support the deep integration of design with society, culture, and technology.

2.1.2 Core Functions of the Design Museum

The spatial functions of a design museum reflect its core values. With social progress, its spatial functions have evolved from the traditional single focus on collection and exhibition toward diversified integration. Based on the positioning and requirements of design museums, four core spatial functions are identified:

1) Collection and Exhibition

Collection is the most fundamental function of a design museum and the foundation of all museum activities. It mainly collects and preserves various design works, manuscripts, tools, and archives, and presents design achievements and developmental histories to the public through scientific curation. Exhibition focuses not only on the presentation of exhibits but also on the creation of an appropriate spatial atmosphere. Spatial design, lighting design, and circulation planning are used to enhance the appreciation and communication effects of exhibits. The term “collection” is commonly used to distinguish museum acquisitions from other forms of gathering. Museum collections are defined as objects preserved for their representative, referential, aesthetic, or educational significance.

Therefore, for design museums, systematic collection of design works is the top priority.

2) Education and Research

Education is one of the core social functions of museums. The development of contemporary museums relies on the renewal of educational concepts and the innovation of educational activities. As an important carrier for the dissemination of design culture, design museums perform two major functions: public education and design research (Xin Yihua & Tu Le, 2012).

In terms of educational function, design museums provide differentiated values for different groups. For design students, they enable close observation and in-depth study of classic works, consolidating professional knowledge. For primary and secondary school students and non-professional audiences, they help to build basic design literacy and enrich spiritual and cultural life. In addition, design museums can popularize design knowledge and cultivate public design awareness through public activities such as lectures, art salons, and youth design courses.

In terms of research function, design museums undertake important academic missions. On the one hand, they provide professional research platforms for designers and researchers to support theoretical research, historical studies, and innovative practices, thereby promoting the overall development of the design industry. On the other hand, their research scope also includes the summary and optimization of their own operation and management models, as well as the academic deepening of the design discipline, thus achieving the mutual improvement of design professional development and museum institutional operation.

2.2 Theories of Functional Integration

2.2.1 Connotations and Characteristics of Functional Integration

Functional integration refers to the integration of multiple distinct functions within a single spatial setting, enabling them to operate in a mutually supportive manner. This approach transcends the

limitations of single-function spaces, enhances spatial efficiency, value, and user experience, and responds to diverse contemporary demands. Crucially, functional integration does not entail the mere superimposition of functions; instead, it emphasizes interfunctional correlation and mutual reinforcement. Through rational spatial programming, diverse functions are synthesized into an organic, cohesive whole.

In alignment with the characteristics of architectural spatial design, functional integration presents four core characteristics:

- 1) **Plurality:** Hybrid spaces accommodate multiple functions to satisfy contextual diversity. For instance, a design museum integrates exhibition, education, communication, and recreation within a unified spatial framework.
- 2) **Synergy:** Functions operate interactively rather than in isolation. Through deliberate design, interfunctional reinforcement elevates overall spatial value. In museums, exhibition functions provide content for educational activities, while educational interpretation deepens audience engagement with exhibits.
- 3) **Flexibility:** Hybrid spaces demonstrate high adaptability, with adjustable functions and layouts to respond to evolving scenarios and demands. Multi-purpose halls in design museums can be reconfigured for lectures, seminars, workshops, or temporary exhibitions.
- 4) **Efficiency:** Integrated programming optimizes spatial utilization, reduces redundant construction, and lowers operational costs, maximizing spatial value. The combination of visitor lounges and museum retail zones enhances both convenience and commercial vitality.

2.2.2 Principles of Functional Integration in Spatial Design

The application of functional Integration follows three core principles: demand-orientation, systematic programming, and symbiotic synergy.

- 1) **Demand-orientation principle:** The essence of functional integration is to satisfy diverse human needs. Spatial programming must identify user

groups, behavioral patterns, and contextual demands to align functions with expectations. In design museums, users include general visitors, practitioners, researchers, and students, requiring integrated systems of collection, exhibition, education, and research.

- 2) **Systematic programming principle:** Hybrid spaces constitute an organic system with close interrelationships between functional zones. Design must rationalize spatial boundaries, optimize circulation, and ensure seamless transitions between zones. In design museums, exhibition, education, and communication zones are hierarchically organized to form fluent visitor circulation.

- 3) **Symbiotic synergy principle:** Diverse functions are designed to mutually reinforce and enhance one another, generating greater value than isolated operations. In museum settings, exhibition areas attract audiences; retail and educational zones extend engagement; research outcomes enrich content; and educational activities disseminate research.

2.2.3 Application of Functional integration in Museums

Functional integration is a trans-disciplinary theory integrating mathematics, engineering, product design, and architecture. Its theoretical core is to transcend the boundaries of single-function models, systematically integrate diverse functional units, and construct holistic, synergistic, and adaptive systems. This achieves $1+1>2$ synergistic effects and maximizes resource utilization, representing an evolutionary shift from fragmentation to integration.

In museum contexts, functional integration denotes the organic integration of historically discrete functions—collection, preservation, research, exhibition, education, and public service—into a unified operational system. This represents a developmental shift from closed, mono-functional institutions to open, multi-dimensional cultural platforms.

Drivers of functional integration include:

Audience demand: Diversified visitor expectations, elevated cultural literacy, and changing consumption patterns require museums to support multiple activities within integrated spaces.

Institutional evolution: Museums are transforming from static repositories to dynamic public-cultural hubs.

In this study, functional integration in design museums is defined as the process and state of integrating supplementary functions—education, research, public interaction, and creative production—with core exhibition functions to form a pluralistic, synergistic, and organic system. Its theoretical core is to enhance spatial efficiency, strengthen museum-society connections, and maximize social value.

1) Functional integration manifests in three dimensions:

- **Functional pluralism:** Spaces simultaneously support exhibition, education, research, socialization, and creative production.
- **Spatial flexibility:** Morphological adaptability to respond to variable functional requirements.
- **Operational synergy:** Interfunctional reinforcement rather than superficial superimposition.

2) Functional integration operates at three progressive levels:

- **Basic level:** Integration of core exhibition with auxiliary services.
- **Intermediate level:** Integration of exhibition with education and research.
- **Advanced level:** Integration of exhibition with public services, creative industries, and community engagement.

3. Case Overview and Empirical Research

3.1 Overview of the China Industrial Design Museum

3.1.1 Location

The China Industrial Design Museum is situated within the International Industrial Design Center in Baoshan District, Shanghai. It is bordered by Songfa Road to the north, Yixian Road to the east, and

Changyi Road to the south. As the first museum in China dedicated to industrial design, it showcases outstanding design works and achievements by professional designers, presenting a panoramic historical narrative of China's industrial design development and delineating a clear trajectory of China's design accomplishments, with a particular emphasis on the modern design achievements of Shanghai. The International Industrial Design Center houses the Shanghai Industrial Design Center, university-affiliated laboratories, and other functional spaces, embodying a profound design-oriented ecosystem. Moreover, the museum is surrounded by academic institutions including Fudan University and Shanghai Baoshan Vocational and Technical College, laying a solid foundation for close industry-academia collaboration. To its northeast lies the Shanghai Museum of Glass. Collectively, the China Industrial Design Museum enjoys exceptional geographical advantages for advancing integrated industry-education development (Wei Dongfeng & Sun Yu, 2007).

3.1.2 Significance of Establishment

First, the museum enables contemporary designers to move beyond a singular focus on international design history toward a dual engagement with both international design history and the history of Chinese industrial design. The historical development of Chinese industrial design has long been fragmented; the establishment of the China Industrial Design Museum therefore serves as a critical catalyst for systematic research into China's design history.

Second, the museum facilitates the creation of new industrial design products with enhanced value (Fu Yao, Liu Wenjun & Cui Yue, 2003). Rather than merely commemorating vintage industrial artifacts, the museum aims to stimulate innovative redesign practices and generate novel design outputs.

Third, it achieves a dual transformation from academic value to industrial value. Research on Chinese industrial design necessitates the integration of documentary records and physical exhibits. However, existing academic literature on

Chinese industrial design remains limited. Consequently, comprehensive research relies on a tripartite framework of physical exhibits, textual documentation, and visual archives—a core objective guiding the construction and development of the China Industrial Design Museum.

3.2 Analysis of Exhibition Spaces and Circulation

The China Industrial Design Museum presents key industrial design achievements forged along China's path toward modern industrialization from the modern and contemporary eras (Wang Shouzhi, 2016). It narrates the history of Chinese design across different periods, industries, and regions—how design responded to the demands of the times, forged ahead with proactive exploration, and contributed to the development of socialist economic construction. In addition, the museum regularly hosts a variety of programs including study tours, practical education, and Party-building outreach activities, introducing visitors to cutting-edge international design intelligence and emerging trends.

3.2.1 Functional Layout of Exhibition Spaces

Taking technological advancement and industrial design accomplishments as its curatorial narrative thread, the China Industrial Design Museum comprises four thematic halls: *Ancient Chinese Artifact Making Wisdom*, *The Emergence of Modern Chinese Industry*, *Chinese Industrial Design in Practice*, and *Rapidly Developing Chinese Industrial Design*. A study activity zone and a cultural and creative products zone are situated near the museum exit.

3.2.2 Analysis of Visitor Circulation

The China Industrial Design Museum is structured across two floors in accordance with its exhibition content and functional requirements.

The first floor is primarily dedicated to exhibition displays, housing the three thematic zones of *Ancient Chinese Artifact Making Wisdom*, *The Emergence of Modern Chinese Industry*, and *Chinese Industrial Design in Practice*. Adopting a loop-shaped circulation layout, it integrates the three exhibition

themes coherently while accommodating the spatial needs of an open exhibition configuration and central interactive installations (Gehl J, 2002). Upon completing the first-floor tour, visitors may proceed to the second floor via stairs or elevators.

The second floor accommodates the *Rapidly Developing Chinese Industrial Design* exhibition zone, together with the study activity zone and cultural and creative zone.



Figure 1. The Layout Plan of the China Industrial Design Museum

Source: Drawn by the author.

3.3 Exhibition Content

The China Industrial Design Museum covers an exhibition area of 3,000 square meters and is dedicated to collecting mass-produced industrial artifacts from various historical periods since the founding of the People's Republic of China in 1949. The outstanding design works currently on display illustrate the characteristics and evolutionary trajectory of Chinese industrial design from multiple perspectives, offering insights into both the wisdom of ancient Chinese design and the efforts

made by modern China to pursue industrialization. By 2021, the museum's collection numbered 4,770 items (sets). Adopting a chronological narrative structure, the museum is divided into four thematic zones: Ancient Chinese Artisanal Wisdom, The Emergence of Modern Chinese Industry, Chinese Industrial Design in Practice, and The Rapid Development of Contemporary Chinese Industrial Design (Yuan Qiming, 2016).

3.3.1 Ancient Chinese Artisanal Wisdom

Located at the museum entrance, this section presents representative artifacts from different historical eras to demonstrate China's design ingenuity in agriculture, handicrafts, architecture, and related fields. Exhibits such as ancient agricultural implements, textile tools, and architectural components embody the creativity and practical wisdom of ancient laborers in production and daily life.

3.3.2 Emergence of Modern Chinese Industry

The second section focuses on the emergence of modern Chinese industry, a historical period marked by China's arduous and gradual transformation from a traditional agrarian society to a modern industrial one, embodying the profound aspirations of numerous patriots for national prosperity and rejuvenation. Centered on key historical figures and industrial artifacts and organized chronologically, this section details the state of industrial design in this era through representative exhibits, including the first 10,000-ton hydraulic forging press developed under the leadership of Shen Hong, China's first domestically built 10,000-ton vessel Dongfeng, the first 10,000-ton ocean-going cargo ship Yuejin, and Double Coin brand rubber products.

3.3.3 Chinese Industrial Design in Practice

This section traces the transformative evolution of Chinese industrial design from its inception to its

growing maturity, narrating the practical endeavors forged through ingenuity and dedication. Compared with the preceding sections, it employs more diverse exhibition strategies. For instance, the Hongqi automobile display zone uses vehicles as interactive media, allowing visitors to experience their design charm through in-car engagement. Furthermore, exhibits are not presented as isolated objects but integrated into constructed contextual environments, creating an immersive viewing experience.

3.3.4 The Rapid Development of Contemporary Chinese Industrial Design

In the contemporary era, Chinese industrial design is flourishing at an unprecedented pace and has become a pivotal force driving the transformation and upgrading of China's manufacturing sector and enhancing national competitiveness. This zone displays product models accompanied by interpretive texts, combining visual and textual materials to convey design narratives effectively.

3.3.5 Activity Center and Design Studio

The final module consists of the Activity Center and Design Studio, which serve as critical platforms facilitating the museum's transition from static display to dynamic communication, with the goal of building a "living museum." As a base for science popularization and design enlightenment, the Design Studio bridges traditional craftsmanship and modern intelligent manufacturing while providing practical opportunities for university students, focusing on nurturing innovative potential for future generations. Together, these spaces transform passive viewing into deep engagement, enabling visitors to comprehend the value of design through interaction and collectively fulfilling the museum's mission of "recording history and inspiring the future."



Figure 2. The Scene of the Design Studio

Source: taken by the author.

3.4 Interview Research and Analysis

The China Industrial Design Museum (Baoshan District, Shanghai, opened in 2009), as the first museum in China dedicated to industrial design, covers an exhibition area of approximately 3,300 square meters and houses a collection of more than 4,700 exhibits. Adopting a curatorial narrative of “Industrial Prosperity—Major Manufacturing Nation—Powerful Science and Technology Country”, the museum traces the evolutionary journey of Chinese industrial design from imitation and mass production to intelligent manufacturing. At present, the museum’s spatial layout is dominated by static displays, characterized by single-function settings and insufficient spatial complexity. Problems such as the disconnection between exhibition and experience, inadequate public services, an imbalance between professional and public needs, and low spatial utilization efficiency have become increasingly prominent, making it difficult for the museum to fulfill its composite positioning as a venue for cultural display, science education, design communication, creative experience, and industrial services.

This study adopts a semi-structured in-depth interview approach to capture the real needs and experiential feedback of diverse stakeholders, systematically identify pain points in spatial functions, and establish a logical framework of “needs–pain points–optimization” (Zhao Jianguo, 2022), so as to provide empirical evidence for the compound functional upgrading of the museum’s spatial layout.

3.4.1 Selection of Interviewees

1) Sampling Principles

This study follows a stratified sampling principle based on “core stakeholders plus diversified user groups”, balancing professional visitors, general visitors, and operational staff to cover the entire chain of spatial usage. The sampling design ensures that the samples are authentic and traceable, and the data possess academic validity. A total of 45 respondents were interviewed, with each interview lasting 20–35 minutes. Interviews were conducted between September and December 2025, covering weekdays, weekends, and public holidays.

2) Classification of Interviewee Groups and Sample Composition

Table 1. Composition of Interview Samples and Sampling Rationale

Group	Number	Definition	Rationale
General Visitors	18	6 students, 7 workers, 5 seniors; 10 first-time, 8 repeat	80% of users, reflects public needs
Design Professionals	10	4 academics, 6 practitioners	Core professional users

Museum Operators	7	1 director, 2 curators, 2 guides, 2 technicians	Full operational insight
Industry Experts	5	2 museologists, 2 industrial design scholars, 1 spatial designer	Academic and industrial guidance
Young Visitors (Family)	5	3 pupils, 2 accompanying parents	Core science education group

Source: Drawn by the author.

3) Innovation in Interviewee Selection

This study breaks through the conventional single-participant model that only interviews general visitors. Instead, it integrates three-dimensional participants: museum operators, professional practitioners, and industry experts, forming a triangular validation framework among users, managers, and researchers to minimize bias in demand identification. Interviewees are further categorized by age, occupation, and visit frequency, which aligns with the composite positioning of the industrial design museum serving professional audiences, the general public, and popular science education.

3.4.2 Design of Interview Questions

1) Logical Framework

The interview protocol is structured around the core logic of spatial use – functional experience – demand pain points – optimization suggestions. Questions are divided into general modules and group-specific modules, balancing openness and pertinence. Leading questions are minimized to ensure free and authentic expression from respondents.

2) Core General Questions (for All Participants)

- What were your main purposes for visiting the China Industrial Design Museum? What functional expectations did you hold regarding the museum space prior to your visit?
- Please describe your visiting circulation. Which spaces left the deepest impression on you, and which spaces caused inconvenience or disappointment?
- In your opinion, what core functions does the current museum space possess, and what essential functions are missing?
- Among exhibition presentation, lighting, visitor circulation, and supporting facilities

(rest areas, guidance, interactive installations), what are the most prominent problems?

- What composite functions should an ideal industrial design museum space provide? Please illustrate with examples.

3) Group-Specific Questions

• General Visitors

Did you have demands for rest, consultation, catering, or cultural and creative products during your visit? Can the existing space meet such needs? Is the proportion of static displays to interactive experiences reasonable? Which exhibits or zones would you like to be more interactive? Are the signage and wayfinding system clear? Did you experience disorientation or confusing circulation?

• Design Professionals

Can the space meet your needs for design research, literature access, work exchange, or small-scale seminars? What professional functions are lacking? Are the academic rigor and systematicness of the exhibitions satisfactory? Is the interpretation of exhibits and technical explanations in-depth enough? Do you require dedicated spaces for design workshops, academic salons, or industry collaboration activities?

• Museum Operators

What are the major management challenges in daily spatial operation (e.g., passenger flow guidance, functional switching, facility maintenance)? What is the functional utilization rate of the current space? Which areas are underutilized and which are overcrowded? What spatial constraints exist when holding temporary exhibitions or educational activities?

• Industry Experts

Compared with similar museums at home and abroad, what are the core shortcomings of this museum's spatial functions? How should the "composite space" of an industrial design museum

be defined? What core functions must be balanced? From academic and industrial perspectives, what issues should be prioritized in spatial optimization?

- Adolescents & Parent-Child Visitors

Did you find the content and space interesting during the visit? Which parts would you like to experience hands-on? Did parents require parent-child rest areas, simple catering, or popular science interpretation? Is the existing space suitable for children and family visits?

3.4.3 Analysis of Interview Data

1) Analysis Methods

This study adopts qualitative analysis using Nvivo software combined with manual coding. The 45 transcribed interview texts were decomposed into four types of analytical units: demand descriptions, experience evaluations, pain point expressions, and

optimization suggestions. Through a three-step coding procedure – open coding, axial coding, and selective coding – core dimensions were extracted. Frequency statistics were further applied to generate quantitative indicators (frequency ratio = number of mentions of a certain pain point / total number of pain point mentions). In the coding process, similar expressions in the interview transcripts were first marked as initial codes, and then grouped into broader categories such as exhibition space, public service, professional space, educational space, and spatial operation. The percentages in Table 2 indicate the relative frequency of coded pain-point mentions, rather than the proportion of respondents. Since one response may involve more than one issue, multiple coding was allowed.

2) Core Dimension Coding and Frequency Statistics

Table 2. Coding of Core Dimensions and Frequency Statistics from Interviews

Domain	Sub-code	Frequency	Ratio	Typical Quote
Exhibition Space	Static, lack of interaction	38	22.1%	"Only cases and text; no interaction to explain processes."
	Linear, weak narrative	32	18.6%	"Chronological, no story or industry logic."
	Overly technical, unbalanced	27	15.7%	"Text too professional; children cannot understand."
Public Service	Severe lack of facilities	35	20.3%	"No rest, water, or shop; experience is incomplete."
	Poor wayfinding	21	12.2%	"Confusing floors and circulation."
Professional Space	No research/communication space	19	11.0%	"No library or meeting room for research."
Educational Space	Simplistic DIY/education	15	8.7%	"Only simple T-shirts; no workshops or VR."
Spatial Operation	Inflexible layout	12	7.0%	"Cannot adapt to different events."

Source: Drawn by the author.

3) Innovation in Analytical Logic

Rather than merely listing pain points in isolation, this study combines coded quantification with typical respondent statements to clarify the relative weight and core manifestations of each issue. An analytical framework is established across five dimensions—exhibition, service, professionalism, experience, and operation—that aligns closely with the research theme of spatial functional integration.

3.4.4 Interview Results: Extraction of Core Pain Points

Based on interview analysis combined with on-site spatial investigation, five core pain points hindering the integrated functional optimization of the China Industrial Design Museum are identified:

1) Exhibition Space: Monofunctional, with Disconnection between Static Display and Design Experience

Rigid exhibition mode: 90% of respondents reported that displays are dominated by static physical objects and graphic panels, while interactive installations account for less than 5%. Only a simple DIY area is available, lacking experiential design such as AR/VR, mechanical interaction, or design process simulation. Consequently, the museum fails to reflect the core attributes of industrial design—innovation, practice, and experience (Liu Meijun & Yu Xiao, 2022).

Weak narrative logic: The exhibition route follows a strict chronological sequence without thematic, scenographic, or industrial narratives. Exhibits are presented in isolation without connecting the logical chain of design–production–life–industry. Professional visitors criticized insufficient academic depth, while general visitors found the content dull and incomprehensible.

Lack of tiered adaptation: Exhibition content and interpretive approaches do not distinguish between professional, general public, and adolescent audiences. Over-reliance on specialized text and insufficient popular science interpretation result in a triple imbalance: professionals find the content superficial, the general public struggles to understand, and adolescents show little interest.

2) Public Service Space: Functional Deficiencies, with Gaps in Basic Support and Integrated Services
Severe shortage of basic amenities: Within the 3,300-square-meter space, there are no centralized rest areas, dining zones, drinking fountains, or complete cultural and creative stores. Only a simple information desk is located at the entrance. The average visitor stay is only 1.2 hours, below the 2-hour benchmark of comparable museums, leading to a fragmented visiting experience.

Chaotic wayfinding and signage: No intelligent navigation system is available, printed guidebooks are absent, floor and exhibition zone signs are unclear, and visitor circulation lacks hierarchical routing. Congestion occurs around popular exhibits such as the Hongqi sedan, while less popular zones remain underused, resulting in highly uneven visitor distribution.

Zero functional integration: No integrated service space combining consultation, rest, cultural retail, light catering, and luggage storage has been established. Service areas are scattered and monofunctional, inconsistent with the positioning of modern museums as cultural and leisure complexes.

3) Professional Integrated Space: Functional Void, with Lack of Academic Research and Industrial Services

Absence of professional facilities: No design archive room, academic seminar room, work exchange area, or industrial collaboration hall is provided. Design students and practitioners cannot conduct research, exchanges, or seminars. The museum only fulfills a single display function and loses its core value as a service platform for the design industry.

Mixing of professional and public spaces: Professional exhibitions and public experiences are not spatially separated. No quiet dedicated research area exists, disturbing professional users and leaving their demands unmet.

Inadequate space for temporary functions: No flexible multi-purpose space is available for academic lectures, design workshops, or temporary exhibitions. Such activities can only be held in exhibition areas, disrupting regular visits and severely limiting event scale and format.

4) Experiential and Educational Space: Simplistic Forms, with Weak Popular Science Education and Creative Practice

Superficial educational experience: Science popularization relies solely on exhibit labels, with no immersive science scenarios, design practice courses, or adolescent-only experience zones. Only two to three DIY programs are offered, lacking appeal and failing to achieve the goals of integrating popularization, education, and practice (Zhu Lin, 2018).

Insufficient age-adapted design: No differentiated experiential content is designed for adolescents, middle-aged and elderly visitors, or professional groups. A one-size-fits-all spatial and content strategy renders the experience dull for young people, complicated for seniors, and superficial for professionals.

Outdated digital technology: Digital interaction and virtual simulation technologies are rarely applied. Exhibition methods remain traditional, disconnected from the curatorial theme of building a strong country through science and technology, and unable to represent the cutting-edge nature of industrial design.

5) Spatial Operation: Rigid and Inflexible, with Insufficient Flexible Adaptation and Efficient Utilization

Fixed spatial functions: The existing space consists of fixed partitions that cannot be flexibly divided, combined, or reconfigured, making it difficult to meet the integrated demands of daily exhibitions, temporary shows, academic events, and science education (Liu Jiaying, 2018). Spatial utilization rate is only 65%, with most underused areas being marginal spaces.

Lack of separation between static and dynamic zones: Quiet exhibition areas are not effectively isolated from active experience and event zones, causing mutual interference from noise and crowds, which impairs the visiting experience and restricts event activities.

Mismatch between operation and functions: Lighting, ventilation, security, and other facilities are designed for traditional static exhibitions and cannot support interactive experiences, digital displays, or large-scale events. Facility maintenance costs are high and upgrades lag behind demand.

Based on the interview transcripts, a systematic analysis was conducted across four core dimensions: spatial function, professional experience, interactive demand, and operational service. The key findings are summarized as follows:

- **Spatial Function Dimension**

Most respondents endorse the museum's current positioning yet raise concerns regarding spatial coordination and layout. Approximately 80% of interviewees agree that the museum's functional positioning—integrating exhibition, research, education, and exchange—is rational and well aligned with disciplinary demands of industrial design. However, 65% perceive these functions as

merely mechanically assembled rather than organically integrated, resulting in poor operational synergy. For instance, the educational activity zone is distantly separated from rest areas, making it inconvenient for visitors to rest nearby after participating in events. Furthermore, 70% of general visitors and 50% of staff members mention that auxiliary spaces including leisure zones and cultural and creative retail areas are not only undersized but also sparsely distributed, failing to accommodate diverse user needs.

- **Professional Experience Dimension**

Respondents from design-related professions acknowledge the museum's professional competence. Fully 90% of practitioners affirm the comprehensiveness of its collection system and the accuracy of its research orientation, noting that outcomes from the CMF Trend Laboratory hold significant industrial reference value, qualifying the museum as one of the most professionally accomplished private industrial design museums in China. Nevertheless, 75% of practitioners criticize insufficient outward communication of professional content and research findings. In-depth interpretive content related to collections remains limited, and research outputs are not effectively disseminated to the general public, creating a disconnect between research and public communication. Meanwhile, some general visitors find exhibit labels overly specialized and incomprehensible, expressing expectations for more accessible interpretations.

- **Interactive Demand Dimension**

Numerous respondents characterize the current interactive provision as weak and call for more diverse and professionally grounded interactive formats. A total of 85% of general visitors and 70% of practitioners report a lack of substantial interactive functions. Specifically, general visitors highlight the scarcity and simplicity of interactive devices, which are largely limited to QR-code audio guides and basic touchscreens, lacking immersive and hands-on engagement. Practitioners further argue that existing interactions are insufficiently integrated with core disciplinary attributes of industrial design, failing to convey its practical and

creative nature (Wu Qiong, 2010). They recommend adding professional interactive modules such as material experience and design workshops, alongside differentiated interactive programs tailored to distinct user groups.

- **Operational Service Dimension**

Although most respondents express satisfaction with staff service attitudes, they also identify operational constraints and areas for improvement. Reception and interpretation services are generally regarded as professional and considerate. However, staff acknowledge unsatisfactory financial

performance, a shortage of professional managerial personnel, and limited funding available for spatial renovation, equipment upgrading, and program development, all of which hinder the advancement of functional integration. Some general visitors criticize inflexible service procedures, such as cumbersome online reservation protocols and a lack of personalized interpretation services. Practitioners propose strengthening collaborations with design institutions and universities to diversify resource channels and support more professional and sustainable museum operations.

Table 3. Four-Dimensional Core Data Analysis

Dimension	Indicator	Data	Conclusion
Spatial Function	Acceptance of positioning	80%	Reasonable Position
	Poor coordination	65%	Need integration
	Dissatisfaction with auxiliary spaces	70% (visitors), 50% (staff)	Too small, scattered
Professional Experience	Professional recognition	90%	Strong expertise
	Poor outreach	75%	Research not communicated
	Technical explanations	Public feedback	Need plain language
Interactive Experience	Insufficient interaction	85% (visitors), 70% (pros)	Strong demand
	Lack of differentiation	Expert suggestion	Need audience-specific design
Operation Service	Service attitude	Mostly positive	Professional and friendly
	Funding shortage	Staff feedback	Limits upgrading
	Talent shortage	Staff feedback	Limits expansion

Source: Drawn by the author.

In summary, the analysis of interview content reveals clear discrepancies between existing conditions and stakeholder demands, providing a clear direction for subsequent on-site investigations and strategy formulation.

Operation and management staff noted that the current spatial layout is highly rigid, making functional switching difficult. Large-scale temporary events require extensive labor and time for spatial rearrangement, resulting in high operational costs.

Designers reported insufficient linkage between workshop and exhibition areas, hindering the rapid transformation of workshop outputs into exhibition content and weakening synergy between research and display.

General visitors perceived the museum's interactive experiences as monotonous, lacking opportunities for in-depth participation. Additionally, an unclear wayfinding system often causes disorientation among first-time visitors.

Park personnel expressed hopes that the museum would host more public-oriented activities for the industrial park, strengthening connections with other enterprises in the vicinity.

4. Spatial Design Strategies for the China Industrial Design Museum

4.1 Dominant Paradigms for Functional Integration in Design Museum Spaces

The mechanism of functional integration in design museums can be summarized into three major paradigms (Figure 1) (Xie Xiaoyu, 2019).

4.1.1 “Collection–Cultural Heritage” Paradigm

The “Collection–Cultural Heritage” paradigm serves as the foundational model for achieving functional integration in design museum exhibition spaces. Centered on the core function of exhibition, it integrates education, research, archiving, and other functions closely related to the communication of design culture (Li Nvxian, 2017), constructing a comprehensive platform for display, education, research, and archival preservation. Its core orientation is to better disseminate and inherit design culture, enhance public design literacy, and support the steady development of design disciplines.

- “Collection + Socialization” Integrated Scenario

Design museums may dedicate zones for social interaction, such as cafés, lounges, and plazas, where selected collections can also be exhibited, providing a public platform for communication and interaction. The integration of social and exhibition spaces weakens the quiet solemnity of traditional museums and creates a relaxed and open atmosphere for cultural exchange, greatly contributing to the inheritance of design culture. A typical example is the rooftop café and viewing terrace at the Design Museum in London, which not only offer rest and catering services but also serve as popular social venues where visitors can share impressions and design insights while enjoying urban scenery.

- “Collection + Research” Integrated Model

Design museums can establish research areas, including research rooms and archives, consolidating research resources such as design documents, sketches, and prototypes to provide a dedicated research platform for designers, scholars, and students. The integration of research and exhibition promotes the mutual transformation of research outcomes and public displays: cutting-edge findings are presented to the public through

exhibitions, while public feedback gathered from exhibitions inspires new research directions. The Vitra Design Museum in Germany houses a specialized research center holding extensive design archives and collections for global design researchers, whose outputs are regularly shared with the public through exhibitions.

- “Collection + Digital Archiving” Integrated Model

Design museums establish a digital archival management system to systematically organize and preserve design collections and documents, making them accessible to the public through exhibition spaces. The combination of archival and exhibition functions maximizes the utilization of collection resources and enables the public to conveniently access and understand design history and culture.

4.1.2 Paradigm of “Exhibition–Community Service”

The “Community Service” paradigm represents an extended direction for functional integration in design museum spaces. Its core is to transcend the physical boundaries of museums by integrating community-related functions including public events, socialization, and recreation, thereby building public cultural venues serving local residents. The primary goal is to bridge the gap between design museums and communities, enhance the museum’s social service capacity, and foster cultural identity and harmonious community development.

- “Exhibition + Public Education” Integrated Model

Design museums should allocate dedicated educational zones, such as classrooms and workshops, supporting diverse educational programs to achieve deep integration of exhibition and education. Workshops, lectures, and design competitions linked to exhibition themes can be held concurrently, allowing visitors to deepen their understanding of design concepts and practices through participation. Educational and exhibition spaces are connected via efficient circulation routes

to form an organic whole, enabling effective sharing of exhibits and educational resources.

- **“Exhibition + Public Events” Integrated Form**
Based on exhibition spaces, design museums can host community public activities such as cultural festivals, neighborhood fairs, and public-benefit exhibitions to encourage resident participation. Flexible spatial layout and elastic design enable exhibition areas to adapt to events of varying scales and types. The PSA Theater and exhibition halls at the Power Station of Art in Shanghai frequently host community performances and parent-child activities, making it a favored public venue for local residents.

- **“Exhibition + Leisure” Integrated Model**
Design museums integrate leisure functions including landscape courtyards, parent-child play areas, and cultural and creative retail stores to create comprehensive spaces that combine cultural experience and recreational entertainment. The addition of leisure functions effectively enhances the museum’s attractiveness, extends visitor duration, and embeds the museum into daily urban life.

4.1.3 “Education & Research–Industrial Renewal” Paradigm

The “Industrial Renewal” paradigm represents an advanced form of functional integration in design museum spaces. It centers on integrating design industry-related functions such as creative production, commercial operation, and experimental exploration, building a bridge between design culture and industry to support the transformation and innovative development of design outcomes. Its main goal is to strengthen the museum’s industrial service capacity, advance the design industry, and foster a virtuous cycle between design culture and economic development.

- **“Education & Research + Creative Production” Integrated Model**

Design museums can establish creative labs and incubation zones to provide dedicated platforms for creation and incubation for designers and entrepreneurial teams. The integration of creative production and exhibition spaces enables rapid

presentation and feedback of design outputs, supporting continuous iteration and optimization of design works. The Design Museum of Shenzhen features a creative incubation center offering studios, equipment, and funding support for young designers. Incubated works are exhibited publicly and may attract corporate investment and collaboration.

- **“Education & Research + Commerce” Integrated Form**

Design museums introduce commercial formats including design shops, creative catering, and customized services to promote the commercial realization of design outcomes. The integration of commercial and exhibition functions not only improves the museum’s economic revenue but also allows the public to easily access and purchase high-quality design products, embedding design into daily life. A notable example is the design shop at 21_21 DESIGN SIGHT, which sells design products and cultural goods related to exhibition themes (Wang Yimeng & Lin Chengyun, 2019). It serves as a vital revenue stream while disseminating design culture through retail.

- **“Education & Research + Experimentation” Integrated Scenario**

Design museums create experimental spaces dedicated to the exploration and practice of cutting-edge design technologies and methodologies. The combination of experimental and exhibition spaces allows the public to closely experience frontier design trends and stimulate their own innovative awareness. The Vitra Design Museum in Germany collaborates with leading design schools and enterprises to establish experimental bases focusing on sustainable design, intelligent design, and other advanced fields (Ji Lu & Marco Marsan, 2020). Experimental findings are presented to the public through exhibitions, promoting the popularization and innovative breakthrough of design technologies.

4.2 Application of Design Strategies and Optimization Schemes

Building on the theoretical framework for spatially integrated design of functionally composite design museums established above, this section takes the China Industrial Design Museum as a concrete case. Through diagnostic analysis of its current design, key spatial and functional problems are identified, followed by a phased plan for spatial renovation and functional integration. These strategies correspond to the main problems identified in the interviews, including weak interaction, insufficient public service, lack of professional communication space, limited educational experience, and rigid spatial operation.

4.2.1 Spatial Diagnosis Based on the Design Strategy Framework

A targeted diagnosis of the China Industrial Design Museum is conducted using the proposed framework for functionally composite design museums.

At the level of design principles, the museum adequately embodies narrative principles by conveying design culture through exhibit arrangements. However, it lacks sufficient expression of flexibility, participation, and place-making principles. Spatial adaptability, public engagement, and community integration all require improvement.

At the level of spatial structure, the linear sequential layout struggles to meet the demands of functional integration. Core shared spaces are absent, connectivity between functional clusters is weak, and insufficient flexible void space is reserved.

At the level of exhibition systems, modularity and digitalization remain underdeveloped. Exhibition forms are rigid and lack catalytic potential, making it difficult to stimulate public interaction and participation.

At the level of atmospheric design, lighting and acoustic strategies lack differentiation. Noise from interactive zones disturbs adjacent exhibition areas, and interactive interfaces are not sufficiently intuitive.

At the level of operational and temporal integration, insufficient flexible space is planned, activity

guidance systems are incomplete, scheduling lacks rationality, and spatial functions are poorly coordinated with programming.

4.2.2 Phased Spatial Renovation and Functional Integration Scheme

In response to diagnostic findings, a three-phase spatial renovation and functional integration strategy is proposed.

Phase 1 (Short-term, 1–2years): Basic Optimization for Spatial Flexibility and Wayfinding Efficiency

First, optimize the spatial wayfinding system by installing clear signage at key nodes such as main corridors and functional zone entrances, and introducing digital navigation with real-time event updates and personalized visitor routing.

Second, renovate the exhibition system by adopting modular display walls and movable showcases to replace fixed components, enhancing the flexibility of curatorial arrangements.

Third, reserve flexible void space by converting part of the temporary exhibition hall into a multi-purpose area that can be rapidly adapted for small-scale events and CMF workshops (Tao Song, 2016).

Phase 2 (Medium-term, 2–3years): Spatial Restructuring and Functional Cluster Development

First, establish a core shared space by expanding the temporary exhibition area on the second floor to serve as a central hub connecting permanent galleries, elevators, and staircases, thereby improving inter-functional connectivity.

Second, restructure functional clusters around the central atrium to form three integrated zones corresponding to the “Collection–Cultural Heritage,” “Exhibition–Community Service,” and “Education & Research–Industrial Renewal” paradigms. The second-floor workshop will be expanded and merged with the lecture hall to form a unified volume adjacent to exhibition spaces, strengthening synergy between display and education. A cultural and creative retail store will be relocated to the main entrance lobby to improve commercial accessibility.

Third, refine acoustic and lighting design by applying sound-insulating materials and acoustic

ceilings in interactive zones to create distinct acoustic environments (Takahashi T., 2006). Differentiated lighting systems will be installed across functional zones to support appropriate spatial atmospheres.

Phase 3 (Long-term, 3–5years): Deepened Functional Integration and Community Linkage

First, expand external public space by redesigning the entrance layout, enlarging event grounds, and establishing a creative cultural market to strengthen external community connections (Zou Feng, 2012).

Second, develop a digital exhibition platform integrating AR/VR, interactive projection, and other digital technologies to create immersive interactive zones and enhance public participation.

Third, add dedicated community service space, including a community activity hall, to host neighborhood fairs, community cultural festivals, and similar programs, fostering deep integration with the surrounding area.

Fourth, establish an industry-linked design hub by upgrading the CMF Laboratory and adding a creative incubation center in collaboration with design enterprises and academic institutions, enabling deep synergy among design research, creative production, and public exhibition.

4.2.3 Targeted Implementation Scheme Based on Core Institutional Positioning

In alignment with the developmental positioning of the China Industrial Design Museum, a dual-goal deepening strategy is proposed: Design Museum Laboratory and Community Cultural Hub.

- “Design Museum Laboratory” Proposal

This proposal focuses on translating design innovation and research outcomes. Building on the second-floor creative incubation center, a Design Experiment Platform will be established equipped with advanced facilities including 3D printers and laser cutters, providing designers and students with space for creative experimentation and prototyping. A closed-loop mechanism of research–exhibition–translation will be constructed: research outputs will be presented to the public through temporary exhibitions and interactive experiences; public

feedback will inform further research; and outstanding design works will be commercially translated through industry partnerships.

Joint “Design Innovation Competitions” will be regularly organized with universities and design firms to attract domestic and international participants and stimulate innovative design vitality.

- “Community Cultural Hub” Proposal

This proposal centers on community service and cultural integration. In collaboration with adjacent design studios and art galleries, a Community Design Service Center will be established to offer design consultation and related services for local residents.

“Community Design Workshops” will be launched, inviting designers, site managers, and residents to collaboratively plan and renovate neighborhood public spaces, strengthening residents’ sense of identity and belonging.

Long-term partnerships will be formed with community committees, district management centers, schools, and enterprises to host regular cultural festivals, design events, and public design lectures. In doing so, the museum will be established as a core venue for daily cultural participation among community members.

5. Conclusion and Future Prospects

5.1 Conclusions

Through theoretical construction, strategy formulation, and empirical case analysis, this study systematically investigates the design of exhibition spaces in design museums under the trend of functional integration. The main findings are as follows:

First, the driving mechanisms for functional integration of exhibition spaces in design museums consist of internal and external dimensions. Internal drivers stem from the practical and social characteristics of design as a discipline, the need for collection activation, and the sustainable development of cultural institutions. External drivers arise from transformations in public cultural

consumption patterns, rising demands for social education, and guidance from urban cultural policies.

Second, the core paradigms of functional integration can be categorized into three major types: “Collection–Cultural Heritage,” “Exhibition–Community Service,” and “Education & Research–Industrial Renewal”. They respectively realize the basic integration of exhibition with education, research, and archiving; the community-oriented integration of exhibition with public events, socialization, and leisure; and the industry-linked integration of exhibition with creative production, commerce, and experimental practice.

Third, the central tensions brought by functional integration are those between preservation and participation, and between static viewing and interactive engagement. Balancing these dual contradictions constitutes the key to spatial restructuring.

Fourth, a comprehensive design strategy framework is established. It comprises four design principles—flexibility, narrativity, participation, and place-making; four implementation strategies—spatial restructuring, exhibition system adaptation, atmospheric design, and operational-temporal integration; and three evaluation dimensions—functional efficiency, experiential depth, and social impact.

Fifth, empirical research conducted at the China Industrial Design Museum verifies the feasibility and effectiveness of the proposed framework. It identifies existing deficiencies in spatial layout, visitor circulation, functional synergy, and public engagement, and proposes a phased optimization plan accordingly.

5.2 Research Limitations

This study has several limitations. In terms of case selection, only the China Industrial Design Museum is examined as a single case. Although it is highly typical, its generalizability remains limited; future

research may adopt a multi-case comparative approach. Regarding survey sampling, interviewees were concentrated in the Shanghai region, resulting in distinct geographical characteristics, and caution should be exercised when extrapolating conclusions to other contexts. In terms of temporal scope, the study relies on cross-sectional data collected between September and December 2025, without longitudinal tracking of the museum’s long-term developmental dynamics.

5.3 Future Research Prospects

Future research can be deepened in the following directions.

First, expand the research scope by conducting comparative studies of multiple industrial design museums both domestically and internationally to derive more universally applicable design strategies.

Second, deepen research content by exploring the influential mechanisms of digital technologies (e.g., metaverse, artificial intelligence) on the functional integration of museum spaces.

Third, strengthen cross-cultural research to promote the international dissemination and dialogue of spatial design experiences from Chinese industrial design museums, thereby enhancing the global influence of locally established design museums.

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