The Role and Model of Interdisciplinary Cooperation in Design Innovation

Qixuan Cheng
Wuhan Univercity of Engineenring Science, Wuhan, Hubei, China

Abstract: Against the dual backdrop of global innovation-driven development and the iteration of digital technologies, the design field is shifting from a single-discipline orientation to an interdisciplinary integration paradigm. By breaking disciplinary barriers and integrating knowledge and methods from multiple fields such as art, technology, humanities, and engineering, interdisciplinary cooperation injects diverse momentum into design innovation and becomes a core path to solving complex design problems and promoting the upgrading of the design industry. Based on the interdisciplinary theoretical framework and combined with practical cases in the field of art and design, this paper systematically analyzes the core roles of interdisciplinary cooperation in expanding the boundaries of design thinking, enriching design methodologies, and enhancing the value of design outcomes; sorts out and summarizes the operational mechanisms and applicable scenarios of typical cooperation models such as project-driven, laboratory-based, and industry-university-research collaborative models; deeply explores the practical dilemmas faced by current interdisciplinary cooperation, such as disciplinary barriers, communication obstacles, and imperfect evaluation systems, and proposes targeted optimization strategies. The research aims to provide theoretical support and practical reference for interdisciplinary innovation practices in the field of art and design, and promote the development of design discipline towards a more comprehensive, scientific, and social direction.
***Keywords*:** interdisciplinary cooperation, design innovation, art and design, cooperation model, collaborative mechanism

1. Introduction

1.1 Research Background

The high complexity and integration characteristics of contemporary society make it difficult for single-discipline knowledge to address real-world design problems that are multi-dimensional and boundary-blurred. Breakthroughs in cutting-edge technologies such as artificial intelligence, digital twins, and biotechnology have not only reshaped the tools and carriers of design but also deepened the cross-penetration between the design field and other disciplines. From the integration of ergonomics and computer science in intelligent product design, to the application of ecology and materials science in sustainable design, and to the combination of anthropology and communication in cultural and creative design, interdisciplinary cooperation has become an inevitable trend in design innovation.

At the policy level, countries around the world regard interdisciplinary innovation as an important starting point to promote the integrated development of cultural and creative industries and technological industries. China's "14th Five-Year Plan for Cultural Development" clearly proposes to "promote the cross-border integration of art with technology, finance, tourism, education, etc., and cultivate new driving forces"; the European Union funds interdisciplinary design projects through the "Horizon 2020" program to strengthen the collaborative innovation between design, digital technology, and sustainable development. At the industrial level, cross-border cooperation between design enterprises, technology companies, and research institutions has become increasingly frequent. For example, Huawei and Tsinghua Academy of Fine Arts jointly develop intelligent terminal interaction design, and IKEA cooperates with environmental protection organizations to explore sustainable material design. Interdisciplinary cooperation has become a key means for enterprises to enhance their core competitiveness.

1.2 Research Status at Home and Abroad

1.2.1 Foreign Research Status

Foreign research on interdisciplinary cooperation and design innovation started early and has formed rich theoretical and practical achievements. In terms of theoretical research, the MIT Media Lab proposed the "anti-disciplinary" research paradigm, emphasizing breaking disciplinary boundaries and promoting disruptive innovation through cross-field collaboration, and its research results have provided important reference for the construction of interdisciplinary design laboratories. Design theorist Rolf Faste integrated interdisciplinary thinking into design education, proposed an interdisciplinary appli-

cation framework of "design thinking", and believed that design innovation needs to integrate multiple dimensions such as technology, business, and user needs. In recent years, with the rise of biological design and digital design, foreign scholars have begun to focus on the application of interdisciplinary methods in sub-fields. For example, Marco Marseglia and others explored the integration path of design and scientific methods through biological design workshop cases, verifying the enriching effect of interdisciplinary dialogue on design outcomes.

1.2.2 Domestic Research Status

In the field of industry and practice, domestic universities and enterprises are actively exploring interdisciplinary cooperation models. Tsinghua Academy of Fine Arts has built a three-dimensional training framework of "art + technology + humanities". Its intelligent interaction laboratory, together with the Department of Architecture, developed the "Wearable Spatial Device", integrating biosensing technology into clothing design and winning international breakthrough design achievements; the School of Design Art at Hunan University invited design anthropologist Wendy Gunn to give academic lectures, promoting the dissemination and application of design anthropology in China, and exploring the application of interdisciplinary methods in fields such as medical care and space. At the enterprise level, Huawei cooperated with university design colleges to establish intelligent material laboratories, promoting the application of flexible electronic technology in furniture design and realizing the commercial transformation of patents; the Palace Museum, together with digital technology enterprises, developed digital cultural relics guide systems using AR, blockchain and other technologies, forming an interdisciplinary design model of "culture + technology".

1.3 Research Content and Methods

1.3.1 Research Content

Taking the role and model of interdisciplinary cooperation in design innovation as the core, this paper mainly includes the following research contents: first, define the core concepts of interdisciplinary cooperation and design innovation, sort out the relevant theoretical basis, and construct the internal correlation framework between them; second, systematically analyze the core roles of interdisciplinary cooperation in expanding design thinking, enriching design methods, enhancing design value, and cultivating innovative talents, supported by art and design cases; third, summarize the typical models of interdisciplinary cooperation in the field of art and design, and analyze the operational mechanism, applicable scenarios, advantages and disadvantages of each model; fourth, explore the current dilemmas faced by interdisciplinary cooperation, such as disciplinary barriers, communication obstacles, imperfect evaluation systems, and uneven resource allocation; fifth, put forward targeted optimization strategies to provide guidance for interdisciplinary innovation practices in the field of art and design; sixth, prospect the future development trend of interdisciplinary design innovation.

1.3.2 Research Methods

This paper adopts a combination of multiple research methods to ensure the scientific and rigor of the research:

(1) Literature Research Method: Systematically sort out relevant literatures such as interdisciplinary theory, design innovation theory, and collaborative governance theory, collect research results, policy documents, and case data on interdisciplinary cooperation and design innovation at home and abroad, lay the theoretical foundation of the research, and clarify the research status and deficiencies.

(2) Case Analysis Method: Select typical interdisciplinary cooperation cases in the field of art and design at home and abroad, including different types such as university interdisciplinary projects, enterprise cross-border design, and industry-university-research collaborative innovation, in-depth analyze the cooperation model, action path, and practical effects in the cases, and extract replicable experiences and inspirations.

2. Core Concepts and Theoretical Basis

2.1 Definition of Core Concepts

2.1.1 Interdisciplinary Cooperation

Interdisciplinary cooperation refers to the process in which researchers and practitioners from two or more different disciplinary fields, based on common goals or complex problems, break disciplinary boundaries, integrate knowledge, methods, perspectives, and resources from their respective fields, and carry out research, practice, or innovation activities through collaborative interaction. Different from the superficial thematic juxtaposition of multi-disciplinary cooperation, interdisciplinary cooperation emphasizes the in-depth integration of knowledge and problem-oriented practical application, pursuing the formation of new ways of thinking, methodological systems, or outcome forms.

2.1.2 Design Innovation

Design innovation refers to the activity of breaking through the traditional design paradigm and creating innovative,

practical, and valuable design outcomes by introducing new concepts, methods, technologies, materials, or forms in the design process. Design innovation includes not only the innovation of physical forms such as products, services, and spaces but also the innovation of conceptual levels such as design thinking, design processes, and design ethics.

Contemporary design innovation presents the development trends of interdisciplinarity, digitalization, sustainability, and humanization. Interdisciplinary integration has become the core driving force of design innovation. By integrating multi-disciplinary resources, design innovation can break through the limitations of a single discipline and better respond to complex user needs and social challenges. Compared with traditional design innovation, design innovation under the interdisciplinary background emphasizes system, comprehensiveness, and coordination, pursuing the balanced unity of multi-dimensional values such as technology, art, humanities, and society.

2.2 Theoretical Basis

2.2.1 Interdisciplinary Theory

Interdisciplinary theory originated in the academic field in the mid-20th century, aiming to break the knowledge fragmentation and closure caused by disciplinary differentiation, and promote the cross-integration and coordinated development of different disciplines. The theory divides interdisciplinarity into three levels: multi-disciplinarity, interdisciplinarity. The multi-disciplinary level refers to different disciplines conducting parallel research around the same theme without in-depth integration of knowledge; the interdisciplinary level refers to breaking disciplinary boundaries, realizing the organic integration of knowledge and methods, and forming new research paths; the transdisciplinary level refers to transcending disciplinary restrictions and freely using multi-disciplinary thinking to solve complex problems in the real world, which is the highest realm of interdisciplinary cooperation.

Interdisciplinary theory emphasizes “problem orientation” and “collaborative innovation”, believing that the solution of complex problems requires the intervention of multi-disciplinary perspectives, and interdisciplinary cooperation can integrate the superior resources of different disciplines to form a synergistic effect of “1+1>2”. In the field of art and design, interdisciplinary theory provides methodological support for design innovation, guiding designers to break through the limitations of traditional design disciplines, take the initiative to dialogue and integrate with other disciplines, and expand the thinking boundary and application field of design.

2.2.2 Design Thinking Theory

Design thinking theory is an innovative thinking model centered on users and aimed at solving problems. Its core lies in generating innovative solutions by integrating user needs, technical feasibility, and commercial value through an iterative process of empathy, definition, ideation, prototyping, and testing. Design thinking has interdisciplinary attributes and can serve as a bridge for communication and cooperation between different disciplines, promoting the integration and transformation of knowledge.

In interdisciplinary cooperation, design thinking plays the role of “integrator” and “guide”. Through the empathy link, designers can guide collaborators from different disciplines to understand user needs and scenarios; through the ideation and prototyping links, it promotes the visualization and materialization of multi-disciplinary concepts, reducing communication barriers; through iterative testing, it realizes the optimization and improvement of multi-disciplinary schemes. Design thinking theory provides a unified operational logic for interdisciplinary cooperation, ensuring that multi-disciplinary resources can efficiently coordinate around innovation goals.

2.2.3 Design Anthropology Theory

Design anthropology theory provides a unique perspective and method for interdisciplinary cooperation, promoting design from “technology-driven” and “aesthetics-driven” to “humanities-driven”. In interdisciplinary projects, qualitative data obtained by anthropologists through fieldwork complements technical data from engineers and aesthetic schemes from designers, enabling design outcomes to be more in line with users’ living habits and cultural backgrounds. For example, Wendy Gunn’s team combined anthropological micro-phenomenological interviews with sensor quantitative data in the hospital air quality optimization project, constructing a more comprehensive design evaluation system, which reflects the value of design anthropology in interdisciplinary cooperation.

3. The Core Role of Interdisciplinary Cooperation in Design Innovation

3.1 Expand the Boundaries of Design Thinking and Stimulate Idea Generation

Traditional design thinking is often limited by the knowledge system and thinking paradigm of a single discipline, making it difficult to generate breakthrough ideas. By introducing thinking modes and perspectives from different disciplines, interdisciplinary cooperation breaks the inherent boundaries of design thinking and provides diverse inspirations for idea

generation. The collision of cognitive logic, research methods, and value orientations of different disciplines can stimulate designers to jump out of the traditional framework and form a new design thinking.

The aesthetic thinking of art disciplines, cultural perspective of humanities disciplines, logical thinking of science and technology disciplines, and practical thinking of engineering disciplines integrate in interdisciplinary cooperation, constructing a multi-dimensional design thinking system. For example, in the "Ink Rhythm · Digital Painting" project of Tsinghua Academy of Fine Arts, the design team combined ink wash aesthetics in traditional art with parametric modeling thinking in digital technology, generated dynamic visual language through algorithms, endowed intangible cultural heritage elements with contemporary vitality, and created works of art with both traditional charm and a sense of technology. In the space station environment design project, the design team integrated the behavioral observation thinking of anthropology, the spatial design thinking of architecture, and the environmental adaptation thinking of physics, systematically analyzed the living behavior and spatial needs of astronauts, provided a new idea for the internal design of the space station, and realized the systematic observation and design application of material culture in the space environment for the first time.

3.2 Enrich the Design Methodology System and Optimize the Design Process

At the research method level, anthropological fieldwork and in-depth interview methods can help designers deeply explore the potential needs and cultural connotations of users, making up for the limitations of traditional user research methods; statistical data analysis methods can conduct quantitative analysis of user behavior, market demand and other data, providing a scientific basis for design decisions; biological life cycle theory can guide sustainable design, realizing the environmental friendliness of design outcomes throughout their life cycle. At the technical tool level, digital technologies such as AI generation algorithms, AR augmented reality, and 3D printing technology, engineering technologies such as biosensing technology and flexible electronic technology, and new environmentally friendly materials in materials science all provide new tools for design innovation, promoting the transformation of the design process from a traditional manual mode to a digital and intelligent mode.

3.3 Enhance the Value of Design Outcomes and Expand the Application Boundaries of Design

In terms of value improvement, interdisciplinary design outcomes can achieve the balanced unity of multi-dimensional values. In terms of aesthetic value, the aesthetic concepts of art disciplines ensure the visual expression of design outcomes; in terms of practical value, the support of engineering and technical disciplines ensures the functionality and feasibility of design outcomes; in terms of social value, the involvement of humanities and social disciplines makes design outcomes more in line with social needs, taking into account fairness, inclusiveness, and sustainability; in terms of economic value, market analysis of business disciplines can help design outcomes better connect with the market and enhance their industrialization potential.

4. Typical Models of Interdisciplinary Cooperation in Art and Design

4.1 Project-Driven Cooperation Model

4.1.1 Model Characteristics

The project-driven cooperation model takes specific design projects as the core link, integrates multi-disciplinary resources around project goals, and sets up temporary interdisciplinary teams to carry out collaborative innovation. This model is characterized by clear goals, strong flexibility, and result orientation. Team members are allocated on demand according to project needs, and the team can be reorganized according to new needs after the project is completed. It is suitable for short-term, targeted design innovation projects.

4.1.2 Applicable Scenarios and Case Analysis

This model is suitable for design projects with strong innovation, complex needs, and short time cycles, such as digital art creation, intelligent product prototype development, cultural and creative projects, and emergency design projects.

Case 1: "Virtual-Real Coexistence" Digital Twin City Design Project of Tsinghua Academy of Fine Arts. Initiated jointly by Tsinghua Academy of Fine Arts and the École Nationale Supérieure des Beaux-Arts de Paris, this project aims at the application of digital twin technology in urban design, and sets up an interdisciplinary team composed of designers, architects, computer scientists, data analysts, and urban planners. The team first clarified the core demand of the project — constructing a digital twin city model with both practicality and artistry, and decomposed the project into four modules: model construction, data collection and analysis, interaction design, and visual optimization; members of each module divided labor and cooperated: computer scientists were responsible for building the digital twin technology architecture, data analysts for urban data collection and processing, designers and architects for model visual design and spatial planning, and

urban planners for professional guidance; the team communicated regularly through a combination of online and offline methods, iteratively optimizing the scheme. The final digital twin city model can not only present the urban operation status in real time but also improve the visual expression through artistic design, attracting students from 23 countries and becoming a model of international interdisciplinary design projects.

Case 2: Interdisciplinary Innovation Project of Smart Wearable Devices by Jiangnan University's School of Design and Xiaomi Group. Jiangnan University's School of Design and Xiaomi Group jointly launched an interdisciplinary smart wearable device project focusing on "health monitoring + scenario-based interaction". The team-including industrial designers, interaction designers, biomedical engineers, data algorithm engineers, market analysts, and Xiaomi's R&D representatives-aimed to break traditional smart bracelet limitations and create a new-generation product with in-depth health management, smooth interaction, and scenario adaptability, as an 8-month short-term targeted initiative. Divided into three core modules: biomedical engineers defined technical thresholds for indicators like heart rate variability via clinical data, guiding algorithm engineers to develop precise models addressing traditional devices' poor accuracy and simplistic interpretation; industrial designers optimized ergonomic device form for comfort and portability, while interaction designers and market analysts researched multi-scenario (sports, office, sleep) user behaviors to design minimalist logic enabling seamless touch/voice switching; Xiaomi's R&D team provided hardware support for sensor integration and battery life optimization, with the team iteratively refining prototypes through user tests. The project yielded a smart bracelet prototype with multi-dimensional health monitoring and scenario-based interaction, securing 3 invention patents and entering Xiaomi's mass production plan. This project-driven collaboration integrated design's user insight/artistic strengths with the enterprise's technical R&D and market resources, delivering product innovation and a replicable university-enterprise interdisciplinary model.

4.2 Laboratory-Based Cooperation Model

4.2.1 Model Characteristics

The laboratory-based cooperation model takes interdisciplinary laboratories of universities, research institutions, or enterprises as platforms, integrates long-term and stable interdisciplinary resources, and carries out continuous design innovation research and practice. This model is characterized by stable platforms, concentrated resources, in-depth research, and long-term cooperation. As a fixed carrier, the laboratory provides comprehensive support for interdisciplinary cooperation in terms of venues, equipment, technology, talents, etc., and is suitable for long-term, systematic interdisciplinary design research and technology research and development projects.

In terms of operational mechanism, the laboratory-based cooperation model adopts a personnel allocation method of "fixed team + mobile experts". The core team is composed of resident researchers from different disciplines, forming a stable cooperative relationship; external experts are invited as mobile members to supplement professional resources according to research needs. The laboratory establishes a regular communication mechanism, knowledge sharing mechanism, and result transformation mechanism, promoting in-depth interdisciplinary research through regular academic seminars, project cooperation, and technical exchanges. At the same time, the laboratory focuses on industry-university-research collaboration, connecting research results with industrial needs to realize technology transformation and industrial application.

4.2.2 Applicable Scenarios and Case Analysis

This model is suitable for fields such as cutting-edge technology research and development, sustainable design research, interdisciplinary methodology exploration, and long-term talent training, such as intelligent interaction design, biological design, digital art technology research and development, and sustainable material research.

Case 1: Interdisciplinary Design Research at the MIT Media Lab. As a world-renowned interdisciplinary research platform, the MIT Media Lab breaks traditional disciplinary boundaries, forms a core team composed of designers, scientists, engineers, artists, and sociologists, and carries out continuous interdisciplinary design research. Guided by the "anti-disciplinary" concept, the laboratory carries out research projects such as intelligent interaction equipment, biological material design, and digital art creation around cutting-edge fields such as digital technology, biotechnology, and artificial intelligence. The laboratory provides advanced equipment and technical support, establishes a regular academic exchange mechanism, and core team members cooperate for a long time to form a stable innovation ecosystem; at the same time, it invites experts from all over the world as mobile members to participate in research, injecting diverse perspectives. The research results of the laboratory not only promote the innovation of design theories and methods but also realize the industrial application of a number of technologies, such as wearable devices and intelligent interaction systems, influencing the development direction of the global design industry.

Case 2: Interdisciplinary Cooperation in Huawei's Intelligent Material Laboratory. Huawei cooperated with university design colleges and materials science research institutes to establish an intelligent material laboratory, focusing on the application of flexible electronic technology in the design field, and forming an interdisciplinary team composed of design-

ers, materials scientists, engineers, and technical researchers. The laboratory is equipped with professional material testing equipment, digital design tools, and prototype production equipment, providing hardware support for interdisciplinary cooperation; establishing a long-term cooperation mechanism, core team members carry out continuous research on the design and application of flexible electronic materials, and develop innovative products such as deformable furniture and intelligent wearable devices through repeated experiments and iterative design. The laboratory focuses on industry-university-research collaboration, quickly transforming research results into patents and commercial products, realizing the unity of technological innovation and market value; at the same time, it cooperates with universities to carry out talent training projects, transporting compound design and technical talents for the industry.

5. Conclusion

With the continuous advancement of digital technology and the upgrading of social demands, the significance of interdisciplinary collaboration in the field of art design will become increasingly prominent. In the future, it is necessary to deepen exploration from both the research and practice dimensions. At the research level, we need to expand the boundaries and methods, focus on exploring the applicable models of cutting-edge technologies. At the practice level, we need to upgrade the collaboration platforms, deepen educational reforms, and strengthen international exchanges. Through continuous theoretical innovation and practical exploration, we can solve problems, optimize models, and promote the improvement and upgrading of design innovation, providing support for the development of cultural and creative industries and the sustainable development of society.

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