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Research on Paradigm Transformation of Luban Woodwork's Intangible Heritage Activation under Participatory Design Theory

Shen Benqiang[a], Zhang Shengbo

Northeast Normal University, Academy of Fine Arts, Changchun, Jilin, 130117, China
[a]1195634925@qq.com

Abstract: *At present, the new format created by the integration of culture and science and technology provides a new path for the intangible cultural heritage activation. In order to break through the traditional one-dimensional mode of intangible cultural heritage protection, this paper puts forward the paradigm transformation research of Luban Woodwork Intangible Cultural Heritage Activation under the participatory design theory. Firstly, the connotation of participatory design theory is analyzed, which is user-centered, integrates multi-stakeholders through democratic participation mechanism, emphasizes the subjectivity of users in design decision-making and realizes design optimization by feedback loop. This paper analyzes the significance of this theory in the revitalization of intangible cultural heritage from three aspects: reconstructing cultural ecology, enabling technological innovation and creating cultural values together. Finally, the specific paradigm transformation path is put forward, and the collaborative mechanism between inheritors, communities and universities is established by activating community subjectivity. It is to reconstruct the logic of value generation, apply cultural anthropological methods to explore the cultural, technical, and economic dimensions of Luban wood art, and thereby establish a value gene repository. Through the application of integrated technology, the threshold of technical participation is lowered, and the seamless connection between physical manufacturing and virtual design of Luban Wood Art is realized. The purpose of this paper is to promote the non-legacy activation of Luban wood art through participatory design theory and provide a solution with both cultural depth and technical feasibility for non-genetic inheritance.*

Keywords: *Participatory design; Luban Muyi; Intangible cultural heritage; Transformation*

1. Introduction

At present, as the wisdom crystallization of Chinese farming civilization, the wood-working skill system represented by Luban Wood Art bears the philosophical thought of harmony between man and nature in its tenon and mortise structure, tool invention and engineering practice[1]. However, the traditional apprenticeship inheritance model faces the risk of skill fault, the substitution effect of industrial production on traditional crafts is intensified, and the young people's awareness of intangible heritage is gradually weakened[2]. At the same time, the integration of culture and science and technology provides a new way for the activation of intangible cultural heritage. Participatory design theory emphasizes the collaborative creation of multiple subjects in the process of innovation, which provides theoretical support for breaking through the traditional one-dimensional model of intangible cultural heritage protection. How to realize the leap of Luban wood art from static preservation to live transmission through paradigm transformation has become a key problem to be solved urgently[3]. The invention logic of tools and the mechanical wisdom of tenon-mortise structure in Luban wood art contain the genetic code of Chinese scientific and technological civilization, and its activation can empower national strategies such as rural revitalization and cultural tourism. Under the background of cultural self-confidence, the activation practice of Luban wood art can enhance the public's sense of identity with traditional culture and promote the creative transformation of Chinese civilization genes.

At present, the research on the inheritance and transformation of wood art is mainly divided into two aspects, namely, technical empowerment and ecological system construction. Some scholars choose to pay attention to the reproduction and dissemination of intangible cultural heritage by digital technologies such as 3D printing and VR. For example, a research team used virtual reality technology to restore the tenon-mortise structure of Yingxian wooden tower and realize the immersion teaching of traditional crafts. At the same time, some studies put forward an innovative ecological model of "culture-technology-industry", emphasizing the dynamic adaptation of intangible cultural heritage to

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modern design and market demand[4]. However, the existing research focuses on a single technology or local links, and lacks a systematic exploration of the multi-agent coordination mechanism in the whole chain of intangible cultural heritage activation, especially the path of value co-creation among traditional craftsmen, designers, consumers and policy makers is not clear.

In this paper, the research framework of paradigm transformation of Luban's non-legacy wood art activation under participatory design theory is constructed. By analyzing participatory design theory and exploring its significance in non-legacy activation, the specific paradigm transformation path is put forward, thus injecting new vitality into the inheritance and development of Luban's non-legacy wood art.

2. Concept analysis

2.1 Connotation and characteristics of participatory design

Participatory design theory is a user-centered design theory, which involves the end users in the design and ensures that the final design is really designed for the end users[5]. Democratic ideology promotes participatory design theory. In participatory design theory, user participation is considered to be valuable in the whole design process, and users are empowered to participate in design by participating in expressing user needs and sharing preferences and ideas. The basic principle of participatory design theory is that users are both the subjects of design and legitimate stakeholders, and their ideas and experiences are very important in design decision-making.

The effectiveness of participatory design theory is not only reflected in its methodology, but also widely reflected in the application of multi-disciplines. In the fields of architecture, technology development and education, participatory design theory can effectively integrate stakeholders from different backgrounds and generate more comprehensive and operational design schemes[6]. The feedback loop and iterative participation mechanism of participatory design theory play an important role in the process of improving the design of practical projects, making the design effect more effective, enabling participants to cultivate a sense of ownership and responsibility, and making the design initiative have a lasting impact.

Participatory design theory and method refers to a method that integrates the needs, opinions and ideas of end users or stakeholders into the design process. Usually, questionnaire survey, design focus group discussion, face-to-face meeting and other ways are used to obtain user feedback and suggestions, and then these feedback and suggestions are integrated into the design, as shown in Figure 1.

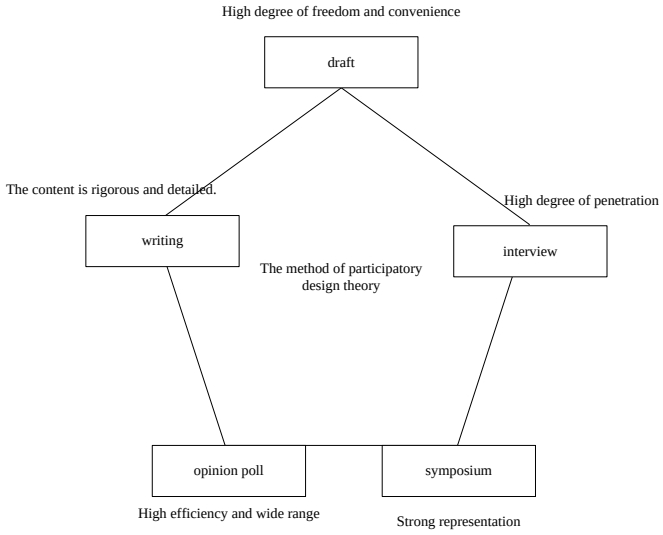

Figure 1: Structural Framework of A Participatory Design Theory and Methodology

Participatory design is a human-centered design philosophy that encourages potential users to actively engage in the design process. Under this approach, individuals can directly express their ideas based on personal needs and contribute to the design itself, moving beyond the traditional reliance of designers solely on their own experience and assumptions to guess user requirements. Participatory design encompasses the entire product lifecycle, allowing users to engage at any stage of the design

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process[7]. This fundamentally shifts the relationship between users, designers, and researchers. Users are no longer merely the target audience of design practices but become core members of the design team. Their relationship evolves toward equality, where all parties function as creators and designers.

2.2 Significance of participatory design

Participatory design is an extensive and complicated social learning process, during which the realization of public interests will be more democratic. Participatory process narrows the distance between users and "specialty", makes users understand the goal of participatory design and realizes the main value of users.

Nowadays, the pace of people's life and the speed of product renewal are accelerating, which urges product designers and researchers to speed up the pace of design and research. In this way, designers and researchers have no time to think about whether users really need it, blindly seek quick results and ignore users' needs, and forget for a long time who the products are designed for, which eventually leads to the design products not being accepted and paid by users. And nowadays, the professional division of labor in the design industry is more and more fine, and designers and researchers are easy to limit themselves to a narrow range. Participatory design allows users to participate in the design[8]. Designers and researchers can slow down and listen to users' ideas, and also take this opportunity to meet more people with different backgrounds, expand their horizons and bring more inspiration and ideas to their creation. If users participate, they can design better works for people, and for designers and researchers, they can also gain a great sense of accomplishment and encourage themselves to create better works with greater confidence. Users' participation in the design is beneficial for developers to understand the real needs of users, so as to adjust the future development direction and strategy, and timely adjust the plans that are contrary to the actual situation in the project, bringing greater economic benefits.

Participatory design can be summarized in two roles: user, researcher and designer, and two key points: one is to mobilize the initiative and enthusiasm of users, and the other is to fully communicate with users by researchers and designers to understand their information use behavior. In addition, there is a supplement, that is, effectively refining user needs[9]. Mobilizing users' enthusiasm and initiative is the basis of participatory design, communication and understanding are the key to participatory design, and effectively refining users' needs is the key. Therefore, participatory design requires the implementation of foundation, key and emphasis.

3. Participatory design theory, the significance of paradigm transformation of Lu Ban's non-legacy wood art activation

3.1 Cultural and ecological reconstruction

Traditional intangible cultural heritage protection focuses on the recording of skills and the cultivation of inheritors, but ignores the integrity of intangible cultural heritage as a cultural ecosystem. Participatory design theory emphasizes the cooperation and co-creation of multi-parties in the process of intangible cultural heritage activation. By constructing a four-element participation mechanism of "inheritor-designer-user-policy party", a pluralistic symbiotic cultural ecology with Luban wood art as the core is formed. For example, the Lubansuo Intangible Heritage Workshop set up by a Luban Tiangong Wood Art Co., Ltd. combines intangible heritage skills with modern enterprise operation through the company-led operation mode to attract rural surplus labor employment and carry out intangible heritage skills training and productive protection[10]. This model not only protects the skill itself, but also constructs a complete cultural ecological chain through market expansion and educational inheritance.

Participatory design in spatial dimension emphasizes the integration of physical space and digital space. As a physical space, the traditional wooden workshop is the physical carrier of skill inheritance, while the virtual workshop built by digital twin technology realizes the visual disassembly and simulation assembly of mortise and tenon structure through 3D modeling and VR interaction, which expands the boundary of skill communication. Social space, through community construction and cultural events, such as Luban Cultural Festival, tenon-mortise structure innovation competition, etc., transforms technical practice into a cultural ceremony of social participation. The cultural ecological field formed by the interweaving of the three can make the activation of Luban wood art transcend the technical level and become a cultural link connecting tradition and modernity, community and society.

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3.2 Technological innovation empowerment

The essence of Luban's wood art lies in the scientific design of tenon-mortise structure and the philosophical thought of harmony between yin and yang, but its traditional inheritance mode relies on the oral instruction of master and apprentice, which has the risk of technical fault. Participatory design theory promotes the upgrading of Luban wood art from experience-driven to data-driven technology paradigm by introducing modern technologies such as digital technology and artificial intelligence. The craftsman skill data recorded by a research team using blockchain technology are shown in Table 1.

Table 1: Artisan Craftsmanship Data Recorded Using Blockchain Technology by a Research Team

Artisan number	Skill type	key parameter	Operation duration (minutes)	Qualified rate of finished products (%)	User feedback score
001	Dovetail Joint Construction	Tenon width: 12mm Mortise depth: 8mm Bevel angle: 45 °	45	98	4.8
002	Corner Tenon Joinery	Three-sided angle: 90 ° Tenon length: 15mm Gluing pressure: 0.5MPa	60	95	4.6
003	Round Tenon Carving	Tenon diameter: 10mm Carving depth: 3mm Rotation speed: 2000 rpm	90	92	4.5
004	Shoulder Tenon Assembly	Shoulder width: 8mm Tenon-groove clearance: 0.2mm Assembly sequence: Horizontal first, vertical second	75	97	4.9

By accumulating a large number of technical data, the research team used machine learning algorithm to build a parametric model of tenon-mortise structure. The model can simulate the structural strength, stability and manufacturing efficiency under different parameter combinations, and provide scientific basis for innovative design[11]. The data in Table 1 shows that technology empowerment can not only improve the efficiency of technology inheritance, but also provide a scientific basis for structural optimization and functional expansion through data precipitation.

3.3 Cultural value creation

The activation of intangible cultural heritage is not only a cultural inheritance, but also a co-creation process of social values. Participatory design theory can transform Luban wood art from a cultural symbol into a social capital to promote rural revitalization and cultural self-confidence building by building a benefit sharing mechanism from the government to enterprises and users. In traditional intangible cultural heritage protection, communities and inheritors are often regarded as protected objects, and their subjectivity is weakened. Participatory design theory transforms communities and inheritors from cultural carriers to value co-creators by giving them decision-making power and discourse power[12]. By participating in the design process, the community can integrate local knowledge such as tenon and mortise skills of Luban wood art into modern design language, so that the intangible products can not only retain the cultural core, but also meet the market demand. In addition, the value of intangible cultural heritage as a cultural symbol is often limited to the preservation of cultural memory, while its value as a social capital is reflected in the promotion of community development, cultural identity and social cohesion. Participatory design theory transforms intangible cultural value into quantifiable social capital by integrating the resources of government, enterprises and users.

From the perspective of skill recording, traditional intangible cultural heritage protection often puts a lot of energy into the detailed recording of intangible cultural heritage skills. For traditional wood carving techniques, protectors will use modern technology to accurately record every carving step and every texture detail of wood carving. Starting from the selection of materials, the types, producing areas and texture characteristics of wood are recorded in detail; Regarding the use of knives in the carving process, it requires precise control over the shape and purpose of each knife, as well as the force and angle applied during carving.Although this recording method completely retains the objective information of the skill, it ignores the rich cultural connotation and humanistic spirit behind the skill. The participatory design theory promotes the re-interpretation and re-creation of intangible cultural significance by introducing the perspectives of external subjects such as users and designers. For example, users' demand for modern functions of Luban Wood Art may inspire inheritors to improve traditional skills and form a new cultural expression of traditional skills and modern design. Designers

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can extract the geometric aesthetics of tenon-mortise structure and apply it to the fields of architecture or products, so as to expand the intangible cultural influence. This co-creation process makes the intangible cultural heritage change from historical memory to living culture, and continuously generates new cultural significance.

4. The paradigm transformation path of Luban Woodwork's non-legacy activation under participatory design theory

4.1 Activate community subjectivity

Participatory design theory emphasizes the status of community as the core subject of intangible cultural heritage activation, and activates the cultural consciousness and innovation ability of community through empowerment and participation mechanism. The inheritance of traditional Luban wood art mostly depends on mentoring or family inheritance, and knowledge transfer is limited to specific groups, which easily leads to the loss of skills. Participatory design breaks the closed inheritance mode by establishing a collaborative inheritance mechanism of inheritors+communities+universities. For example, a wood art company takes provincial inheritors as the core, establishes a heritage training group, combines step-by-step teaching with skill practice teaching, and decomposes core skills such as mortise and tenon structure and carving technology into modular courses, which are open to community residents. In addition, it is necessary to establish a physical platform and a digital platform for participatory design. The physical platform includes non-legacy workshops, innovation laboratories, cultural industrial parks, etc., providing a place for face-to-face collaboration among multiple subjects. For example, the Luban Wood Art Collaborative Innovation Center can be set up to integrate university design resources, enterprise market resources and community skills resources, and promote knowledge flow and technology sharing among subjects through regular workshops, design competitions and other activities[13]. The digital platform needs to use blockchain and other technologies to build a non-legacy activation knowledge base and collaborative network. By storing the parametric model of traditional tenon-mortise structure and the skill videos of community inheritors, real-time collaboration and knowledge tracing across subjects and regions can be realized.

4.2 Reconstruction of the Value Generation Logic of Intangible Heritage Activation

The core of participatory design theory is to reconstruct the logic of value generation through the cooperation of multiple subjects and realize the organic unity of cultural value, economic value and social value. In this regard, cultural anthropology and other methods can be used to deeply explore and systematically establish the cultural value and economic value of Luban wood art. For cultural value, we can dig out the philosophical thought and aesthetic characteristics behind it, while for technical value, we need to focus on analyzing the mechanical principle and material processing technology of its tenon-mortise structure, so as to dig out sustainable design wisdom[14]. This process of value identification needs to be completed through interdisciplinary team cooperation, thus forming the value gene bank of Luban Wood Art, which provides a basis for subsequent value transformation.

The value identification result based on Luban Wood Art can be the basis of its corresponding value transformation path. In this regard, the tacit knowledge in traditional techniques can be transformed into coding design parameters, and the mortise and tenon splicing actions of inheritors can be recorded by motion capture technology, which can be transformed into robot operation instructions, so as to realize the digital reproduction of traditional techniques. In the transformation from culture to market, it is necessary to develop products that meet the needs of modern consumption through user research and market testing. For example, modular mortise and tenon furniture can be designed for young people, and the free combination and personalized customization of furniture can be realized through APP to enhance the user experience. Then, an evaluation system of the activation value of Luban Woodwork is constructed, which covers many dimensions, such as cultural wear and economic benefits. Real-time monitoring is realized through the digital platform, and the activation strategy is dynamically adjusted according to the evaluation results. If the user satisfaction of a certain product is found to be low, designers, inheritors and users can be quickly organized to carry out collaborative innovation and optimize product design.

4.3 Technology integration application

Participatory design theory needs to rely on modern technology to promote the technical upgrading of Luban wood art activation and realize the transformation from static preservation to dynamic

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creation[15]. Therefore, it is necessary to integrate digital twinning and 3D printing technologies to form a closed-loop technology for the activation of Luban wood art. Digital twinning technology can transform the traditional tenon-mortise structure into a parametric model, thus realizing the seamless connection between virtual design and physical manufacturing. At the same time, we can also use artificial intelligence technology to analyze user preferences through machine learning, so as to automatically generate a design scheme that meets market demand. For example, the "Luban Muyi AI Design Platform" can be developed. Users can automatically generate a variety of mortise and tenon structure design schemes by inputting furniture size and style preferences, and can make prototypes through 3D printing for users to choose and optimize. In addition, it is necessary to develop collaborative tools suitable for multi-agents to reduce the threshold of technical participation. Community inheritors can use the visual design tool of tenon-mortise structure to realize the rapid design and modification of tenon-mortise structure through drag-and-drop operation. Designers can integrate cultural elements such as patterns and colors of Luban wood art through cultural element library tools. These tools need to be highly compatible and support cross-platform use, so as to promote the efficiency of collaboration among agents.

5. Conclusion

Under the participatory design theory, Luban's wood art has been revitalized, and the paradigm transformation from cultural symbols to social capital has been realized through the reconstruction of subject relationship, the logical transformation of value generation and the innovation of technology empowerment path. This transformation not only improves the sustainability of intangible cultural heritage activation, but also provides a replicable and scalable model for the modern transformation of traditional crafts through multi-agent cooperation and technology integration.

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