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Research on the Exhibition Rack Construction Design of University Art Museums Based on Modular Theory

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Abstract: *The role of art museums in art education and social cultural dissemination has become increasingly prominent, and their exhibition spaces have evolved towards diversification and specialization. However, issues such as storage difficulties, space occupation, low assembly efficiency, and high material consumption have emerged. Modular theory emphasizes the standardization, combinability, and variability of modules. Introducing this theory into the design of exhibition racks in university art museums can enhance exhibition setup efficiency, facilitate flexible use of space, and encourage innovation in exhibition formats. Based on this, this paper starts from the basic principles of modularity, analyzes the current status and issues in exhibition rack design in university art museums, explores application strategies for modular thinking in rack construction, and proposes a method for constructing exhibition rack systems centered on standardization, combinational transformation, and functional expansion. This approach provides theoretical and design references for the sustainable operation and innovative development of exhibition spaces in university art museums.*

Keywords: *Modularization, Exhibition Rack Design, University Art Museums, Structural Analysis*

1. Introduction

The role of art museums in art education and social cultural dissemination has become increasingly prominent, and their exhibition spaces have evolved towards diversification and specialization.[1] However, issues such as storage difficulties, space occupation, low assembly efficiency, and high material consumption have emerged. Modular theory emphasizes the standardization, combinability, and variability of modules. Introducing this theory into the design of exhibition racks in university art museums can enhance the efficiency of exhibition setup, facilitate flexible use of space, and encourage innovation in exhibition formats. Based on this, this paper starts with the basic principles of modularity, analyzes the current status and issues in exhibition rack design in university art museums, explores application strategies for modular thinking in rack construction, and proposes a method for constructing exhibition rack systems centered on standardization, combinational transformation, and functional expansion. This approach provides theoretical and design references for the sustainable operation and innovative development of exhibition spaces in university art museums.

2. Modular Theory and Its Research Status

2.1 Definition of Modular Theory

In his 2000 book Ten Thousand Things: Module and Mass Production in Chinese Art[2], Ledderose first introduced the concept of “modules” in traditional Chinese art. He described a system where standardized parts are used to assemble objects. These parts were prefabricated in large quantities and could be quickly assembled in various combinations, creating an extensive variety of units from a limited repertoire of components. These components are called “modules”.[2] A sequence of modules is typically divided into five levels, from simple to complex: element — module — unit — series — mass. [3] The concept of modularity originates from ancient Chinese craftsmanship, and its core lies in achieving large-scale production and diverse innovation through standardized, interchangeable modules combined in a hierarchical manner. Its key features include: standardization and interchangeability (modules are standardized, independent components that can be reused in different combinations); hierarchical and systematic structure (the module system is divided into multiple levels, from basic elements to complex

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units); and flexibility and adaptability (modules can be adjusted in size and combination according to different needs, fitting various scenarios).

2.2 The Application Status of Modular Theory in Exhibition Design

Modular design in exhibition spaces has developed relatively maturely in developed countries such as those in Europe and North America.[4] Design agencies in countries like Germany, the Netherlands, and the UK have widely applied modular systems in temporary exhibitions, art installations, and educational touring exhibitions. Brands such as Vitra (Figure 1) and IKEA have continuously developed standardized display modules, enabling rapid global deployment and reuse. Meanwhile, scholars abroad have conducted research on exhibition rack modular systems from various perspectives, such as architectural modules, sustainable system design, and interactive space construction, emphasizing their potential to enhance cultural dissemination efficiency and implement green design strategies.[5] However, in China, research on modular design started relatively late. In recent years, with the rapid development of the exhibition economy and the cultural heritage exhibition industry, related theories and practices have gradually advanced. Currently, academic research mainly focuses on modular design methods for exhibition booths and spaces,[6] exploration of green exhibitions and sustainable materials,[7] application strategies in specific scenarios,[8] and the use of digital and parametric technologies.[9] Despite the continuous emergence of practical cases, systematic theoretical research and standard development remain incomplete. Most projects still rely on experience-based design and lack a unified modular system and cross-project transferability.

Figure 1: Kubirolo.

Specifically, the application of modular design in exhibitions faces several major issues. First, there is a disconnect between theory and practice. Although modular theory has developed a relatively complete system in architecture, furniture, and industrial design,[4] it is still in its early stages in exhibition design, mainly focusing on “quick assembly” or "reuse," and lacking systematic integrated research.[5] In practice, temporary construction is the primary approach, and effective standards and methodologies have not been established. Secondly, there is a lack of standardized modular systems. Exhibition module designs lack unified standards, such as size modules, interface standards, and load performance, resulting in incompatibility between modular systems across different projects, which increases repetitive designs and material waste.[10] Additionally, there is a serious issue of spatial homogenization, with some exhibition rack designs overly emphasizing structural functionality while neglecting the emotional experience, aesthetic expression of space, and the supporting role of module forms in exhibition content, rhythm, and atmosphere.[11] This leads to exhibition spaces becoming homogenized and lacking sufficient visual appeal. Finally, although modular systems have the ecological advantages of easy disassembly and recyclability, most exhibition projects currently lack a lifecycle management mechanism. After the exhibition ends, the absence of a well-established recycling, maintenance, and reuse system results in the scrapping of a large number of exhibition racks, causing resource waste.[12]

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This contradicts the sustainable design concept of "minimal intervention — maximum reuse" in modular theory.

3. Analysis of Exhibition and Exhibition Rack Design in University Art Museums

3.1 Exhibition Characteristics of University Art Museums

University art museums are institutions within higher education establishments, such as universities or colleges, that focus on collecting, exhibiting, and researching artworks.[13] As important carriers of campus culture and art education, their exhibitions are characterized by strong academic, experimental, and teaching service orientations. Compared to commercial art museums or national-level art institutions, university art museums take on more functions, including displaying teaching achievements, promoting academic research, and disseminating culture.[14] Exhibition content includes graduation exhibitions, course result presentations, contemporary art experimental exhibitions, and more. Overall, exhibitions are held frequently, with flexible pacing and diverse formats, requiring efficient setup within limited space and budget.[15] These exhibitions are typically not aimed at commercialization but focus on exploring artistic language and fulfilling educational functions. Therefore, they have diverse functional demands for exhibition installations, including ease of setup, reusability, visual appeal, and interactive compatibility.

3.2 Functional Analysis of Exhibition Racks in Exhibition Composition

Exhibition racks, as a key component of exhibition design, not only serve basic functions such as supporting exhibits and dividing space but also play an essential role in the language of the exhibition space. A well-designed rack system can effectively guide visitor flow, strengthen the expression of exhibition themes, and even directly shape the narrative structure of the exhibition.[16] Particularly in university art museums, the design of exhibition racks must support teaching objectives and the presentation of experimental art, featuring highly modular characteristics and functional compatibility. For example, it should accommodate the display of various types of exhibits, including paintings, sculptures, videos, and interactive installations. Some universities have begun experimenting with modular exhibition rack systems to meet the rapid deployment and spatial adaptation needs of different exhibition themes. This system not only improves work efficiency but also serves as a platform for interaction between art design teaching and student creations.

3.3 Current Status and Issues of Exhibition Rack System Design

3.3.1 The Exhibition Racks are Large in Volume and Occupy Space

Many traditional exhibition racks use large, non-foldable or non-detachable structures, such as wooden frames and steel frameworks, which occupy significant storage space. University art museums or art college teaching spaces are often constrained by limited space and lack independent storage for exhibition equipment. As a result, exhibition racks end up occupying classrooms, studios, and other teaching resources for extended periods, leading to conflicts between teaching activities and storage needs.

3.3.2 Exhibition Racks Depreciate Quickly and Have a Low Recovery Rate

Due to issues such as improper transportation, disassembly, and stacking, many exhibition stands are damaged or structurally deformed after being used only once or twice, rendering them unusable. The lack of a professional storage and maintenance system exacerbates physical wear and shortens the lifespan of the stands, creating a vicious cycle.

3.3.3 Low Efficiency in Assembly and Disassembly

The assembly process of some traditional exhibition stands involves complex structural connections and procedures, requiring skilled technicians to use various tools. This not only increases the difficulty of assembly but also prolongs the setup time. Similarly, during the dismantling process after the exhibition, considerable effort is required, and the stands are prone to damage, which affects their reuse.

3.3.4 High Consumption of Materials and Serious Resource Waste

Due to the high level of customization of traditional exhibition stands and the lack of effective modular design, many components cannot be reused in other exhibitions after the event. As a result, they

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are often discarded or left idle, leading to significant resource waste.[17] This issue is particularly prominent with custom-built exhibition booths designed for one-time use.

3.3.5 Lack of Personalization and Innovation.

Although traditional exhibition stands come in various types, their shapes and display forms are relatively simple in practice, due to limitations in structure and assembly methods. They struggle to meet the demands of modern temporary exhibitions for personalized and innovative presentation effects, failing to fully capture the audience's attention or enhance their exhibition experience.

These issues largely constrain the diversity and sustainable development of exhibition activities in university art galleries, and are at odds with the current trends emphasizing "green exhibitions" and "sustainable design".

4. Design Strategy for Exhibition Stand Composition under Modular Theory

4.1 Components of an Exhibition Stand

4.1.1 Load-bearing System

The load-bearing system is the foundational component of temporary exhibition stands, primarily responsible for supporting the weight of the entire structure as well as the exhibits. It is usually made of metal frameworks such as aluminum alloys, steel, and other materials. Its design must consider factors like the stand's height, dimensions, and the weight it needs to bear, ensuring the stability and safety of the stand.[18] Under the modular theory framework, the load-bearing structure can be divided into several standard-length modules and units (such as columns, beams, support legs, etc.), which are quickly assembled using standard connectors, making them easier to transport, store, and reuse.

4.1.2 Display Panel

The display panel carries visual information and serves as the first interface through which the audience interacts with the exhibition content. Common materials for display panels include wood, acrylic, glass, PVC, and others. The shape and size of the display panels should be designed according to the characteristics of the exhibits and the exhibition requirements, while also ensuring compatibility with the load-bearing system.[19] Under the modular theory, the display panels are designed with standardized dimensions, supporting both horizontal and vertical splicing, which facilitates combination with load-bearing systems of different specifications, enhancing the flexibility and diversity of the exhibition display.[6]

4.1.3 Connectors

Connectors are key components that enable the connection of various parts of the exhibition stand, and their quality and design directly impact the overall performance of the stand. There are various types of connectors, such as bolts, nuts, clips, pins, and others.[18] In modular theory, connectors must meet the requirements of standardization and universality, enabling easy and quick connection of different modules, while also ensuring the strength and stability of the connections. For example, using standardized bolt-and-nut connections can facilitate the rapid assembly and disassembly of metal frame modules, improving the installation efficiency of the exhibition stand.

4.1.4 Auxiliary Facilities

To enhance the exhibition effect, stands are often equipped with auxiliary facilities such as lighting systems, sound systems, and display props. These facilities must be coordinated with the main structure of the stand to ensure ease of installation and use. During the modular design phase, installation interfaces (such as lighting tracks, cable routing channels, etc.) are reserved, allowing auxiliary functions to seamlessly integrate into the main structure, thereby improving the overall functionality of the stand. For example, LED strips can be embedded along the edges of the display panels to create focused lighting, and power modules can be integrated into the columns to provide power support for interactive devices.

4.2 Analysis of Composition Methods

4.2.1 Modular Composition Logic of Exhibition Stand Systems

Based on the components of the exhibition stand, it can be classified according to the five-level

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modular composition system, sequentially divided as shown in Table 1: "individual parts — standard accessories — individual exhibition stands — combined exhibition stands — overall exhibition stand system." The specific composition logic is illustrated in Figure 2, which outlines the structural logic of the wall-mounted display rack. The elements of the wall-mounted stand are integrated according to the logical order of "elements — modules — units — series — mass," leading to the progressive composition relationship: "rods + fasteners — frame + panel material — exhibition panels — wall-mounted panels — the wall-mounted display rack system that integrates storage and exhibition."

The system begins with basic elements such as rods and connectors, which combine to form modules with basic structural functions. These modules then form display units that can be used independently. Multiple units are arranged in an orderly manner to create a continuous display surface, ultimately forming a complete wall-mounted system with both display and storage functions.

Each part and module should undergo standardized design, determining parameters such as size, shape, materials, and connection methods.[6] This enables mass production, reduces manufacturing costs, and improves the universality and interchangeability of the modules. In the initial modular design, functional expansion interfaces should be reserved, such as lighting tracks, power wiring channels, and movable wheelbases, to accommodate future exhibition needs. At the same time, the connection strength and stability between modules must be fully considered to ensure the safety and reliability of the stand during use.

Table 1: Modular Composition Logic of Exhibition Stand Systems

Modular Composition Logic of Exhibition Stand Systems					
Field	Element	Module	Unit	Series	Mass
Chinese characters	Individual strokes	Constituent	Individual Chinese character	Coherent text	All Chinese characters
Exhibition rack	Individual parts (bolts, clips, connection slots, pins, rivets, magnetic strips, rubber washers, etc.)	Standard accessories (columns, beams, pulleys, display panels, bases, top covers)	Individual exhibition stands (standard booth units, display cubes, exhibition wall segments, lighting frame units)	Combined exhibition stands (linear exhibition walls, zigzag paths, circular passages, grid layouts)	Overall exhibition stand system (integrated exhibition space, exhibition area layout structure)

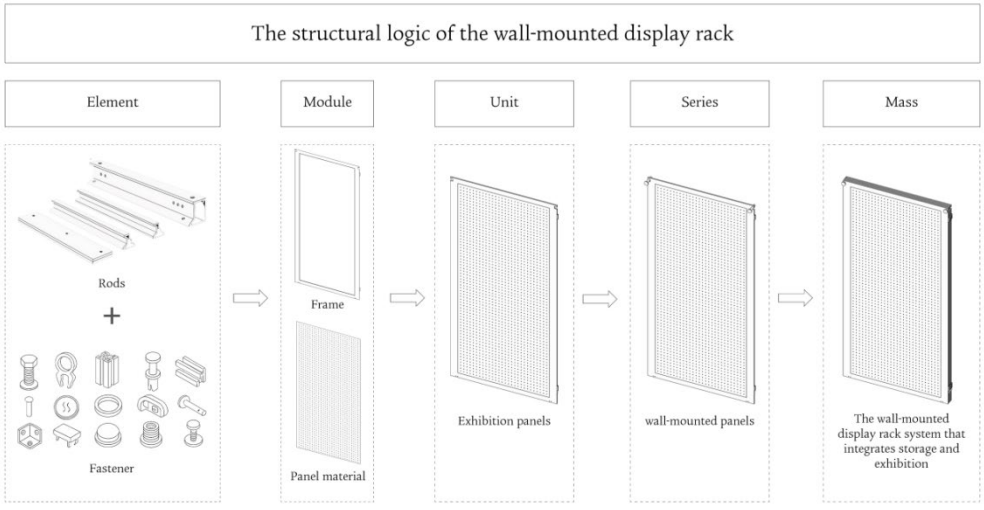

Figure 2: The structural logic of the wall-mounted display rack.

4.2.2 Combination and Variation Design Method

Based on different exhibition requirements, appropriate modules are selected for combination or interchange to create a diverse exhibition composition. This approach aligns with the principle of highly standardized modules replacing exact replicas, as explained by Redholt in his work: standardized modules, while differing slightly in shape, allow for richer forms of expression.[20] Through optimizing

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the combination methods, connection sequences, and positioning of the modules, the unity of the stand's function and form can be achieved.

For example, in the independent display stand section shown in Figure 3, side-by-side, three-sided, and four-sided stands are configured according to different display needs. At the same time, the same batch of modules can be quickly assembled into partition walls or interactive zones. By simply replacing the surface materials or colors, the exhibition atmosphere can be easily altered.

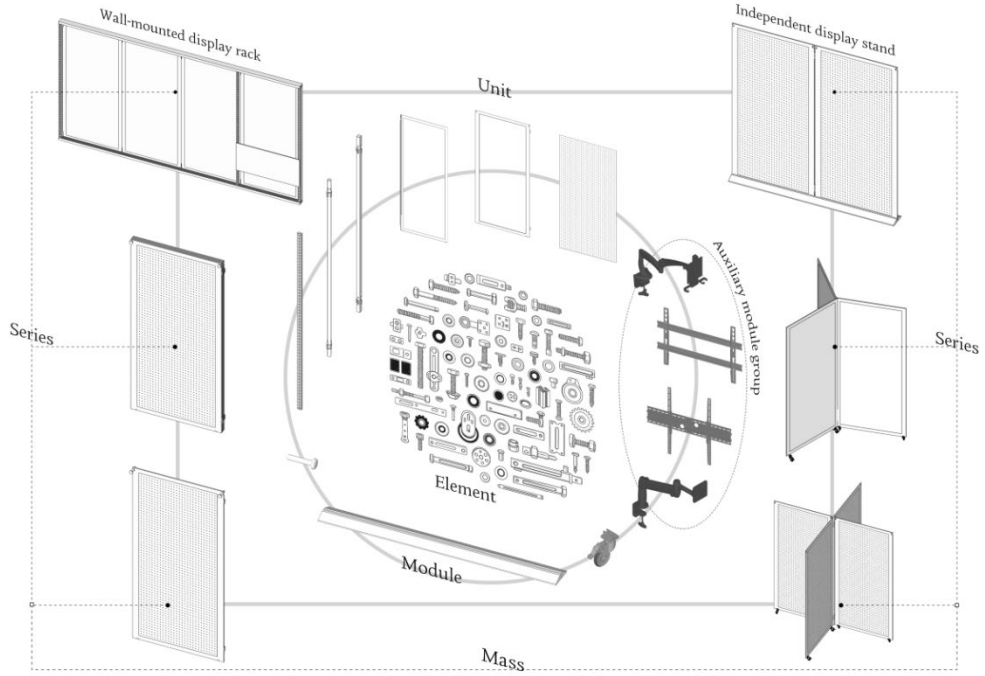

Figure 3: Schematic Diagram of Modular Exhibition Stand System.

4.2.3 Module Update and Expansion

With changes in exhibition needs and the development of technology, the modules of exhibition stands can be updated and expanded. When new display functions or technologies need to be incorporated, it is only necessary to replace or add the corresponding modules, without the need to redesign or manufacture the entire stand. For instance, when multimedia display functions need to be added, a multimedia display module, such as the auxiliary module group shown in Figure 3, can be designed and connected with existing stand modules to achieve the multimedia display effect. This approach to module updates and expansion not only meets the ever-evolving demands of exhibitions but also extends the lifespan of the stand and improves the efficiency of resource utilization.[21]

4.2.4 Material and Technology Selection

The selection of materials and technologies for exhibition stands directly impacts their structural performance, assembly efficiency, aesthetics, and environmental adaptability. During the design phase, factors such as load-bearing requirements, ease of assembly and disassembly, sustainability, and cost control must be considered comprehensively. To address this, the commonly used materials for exhibition stands, along with their characteristics and limitations, are summarized in Table 2.

Table 2: Comparison of Common Material Types and Their Properties.

Material Types	Characteristics and Advantages	Applicable parts	Limitations
Aluminum profiles	Light in weight, high in strength, corrosion-resistant, easy to process and highly standardized	Load-bearing structure, frame components	Cost slightly higher
Steel	Extremely high strength, suitable for large load-bearing structures	Main load-bearing structure, base	Heavy, inconvenient to transport
Wooden board	Easy to shape, strong surface decoration ability, and relatively low cost	Display panel, decorative panel	Prone to deformation due to moisture

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Composite material	Such as PVC boards, honeycomb panels, sandwich panels, etc. These are lightweight, impact-resistant, and have moderate strength	Exhibition panels, lightweight partitions	Not suitable for load-bearing structures
Acrylic glass	Good transparency, strong modern feel, and can be sculpted	Display window, light box panel	Prone to scratching
Environmentally friendly materials	Such as recycled plastics, bamboo, recyclable aluminum, etc., to reduce environmental impact	Various components	Durability needs to be evaluated
3D printing materials	Suitable for non-standard connectors and custom structural components, facilitating rapid manufacturing and prototype validation	Connection nodes, special decorations	High cost, weak load-bearing capacity

In terms of technology selection and integration strategy, modular standardization manufacturing techniques are employed. High-precision processes such as CNC machining, laser cutting, and profile extrusion ensure uniform module dimensions, improving compatibility and interchangeability, thereby laying the foundation for quick assembly. The use of an integrated connector system design, utilizing standardized connectors (such as quick-release fasteners, magnetic clips, threaded locks, etc.), enables tool-free assembly and efficient disassembly, enhancing the efficiency and flexibility of exhibition setup.[7]

Embedded functional integration technology is used by pre-setting power cable slots, lighting tracks, audio module interfaces, and other functional connectors within the modules. This gives the stand multimedia display capabilities while avoiding exposed wiring that could impact aesthetics and safety. A sustainable material utilization strategy is implemented, with a preference for recyclable materials (such as recycled aluminum and regenerated plastics) or reusable components for module selection, extending their usage cycle and reducing resource waste after exhibitions, in line with green design principles. Finally, digital custom manufacturing is employed, using parametric design and BIM models to create a module database. This enables customization of dimensions and structures according to specific exhibition needs, achieving a balance between personalization and systemization.

The selection of materials and technologies for modular exhibition stands should strike a balance between structural performance, display effect, environmental sustainability, and cost-effectiveness. Aluminum profiles and composite materials are suitable for the widespread use of standard modules, while wood and 3D-printed parts are more appropriate for local decoration and creative structures.[17] At the same time, standardized connection technologies and functional integration design are key factors supporting the efficient assembly and sustainable use of modules.

5. Conclusions

This article delves into the concept of modular design, addressing the existing issues and demands in the exhibition stand design of university art galleries. It proposes a modular theory-based composition strategy for exhibition stands. Guided by modular design principles, the design and construction of the stand system not only provide flexible and efficient solutions for exhibition spaces in university art galleries but also promote the sustainability and innovative development of these spaces. By utilizing standardized modules, optimizing combination logic, and establishing flexible mechanisms for variation and updates, modular exhibition stands can significantly enhance the efficiency of exhibition setup, simplify spatial configuration processes, and maintain excellent adaptability and functionality over multiple uses. Moreover, these stands can diversify the exhibition theme through various combination and variation methods.

In addition, material and technology selection plays a crucial role in modular design. It is essential to balance structural performance, display effects, and environmental sustainability by using sustainable materials and efficient connection technologies, ensuring the long-term usability and environmental adaptability of the stand system.

However, despite the significant potential of modular design in university art gallery exhibition spaces, there are still challenges such as an incomplete standardization system, insufficient project compatibility, and a disconnect between design and actual needs. Therefore, future research and practice should focus on further exploring the construction and unification of modular design standards to enhance the universality and transferability of modules. At the same time, considering the unique functional needs of university art galleries, more intelligent and interactive exhibition stand systems

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should be developed, offering more convenient and efficient exhibition solutions for art communication and cultural education.

In summary, through the in-depth application of the modular design concept, university art galleries can not only enhance the flexibility and display effect of exhibition spaces but also maximize resource utilization and drive continuous innovation in exhibition methods. In the future, with the ongoing advancement of technology and the evolution of design concepts, modular exhibition stand systems will play an increasingly important role in the field of art display. They will also provide university art galleries with crucial theoretical foundations and design approaches for offering higher-quality exhibition experiences, achieving efficient resource utilization, and promoting green and sustainable development.

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