

Research on Integration Strategies of Modular Furniture Design based on Sustainable Concept

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Abstract: In accordance with the principles of sustainable development, modular furniture design integrates traditional Chinese bamboo weaving elements with mortise-and-tenon joints. The background of modular furniture design involves multiple fields such as environmental protection and sustainability, market demand and innovation, traditional craftsmanship and structural advantages, as well as modern needs and heritage. These factors collectively drive the development and innovation of modular furniture design. This design combines sustainable concepts, modular furniture, traditional mortise-and-tenon techniques, and bamboo weaving craftsmanship to create environmentally friendly yet practical furniture pieces. Using renewable bamboo materials as the primary component, the design employs bamboo weaving techniques to endow furniture with natural aesthetics and breathability. By adopting modular design concepts, the furniture can be freely assembled and disassembled according to spatial requirements, enhancing flexibility in use and resource utilization efficiency. Traditional mortise-and-tenon joints are utilized without relying on adhesives or metal connectors, ensuring stable durability, extending service life, and reducing waste generation. The overall design embodies reverence for nature and awareness of resource conservation, leading a new direction for green living.

Keywords: Sustainable Concept; Bamboo Weaving; Mortise and Tenon; Modular Furniture

1. Introduction

With rising living standards and expanding demands for quality lifestyles, modular furniture design has become a key component of whole-house customization, gaining

widespread adoption. The sustainable concept holds significant importance in furniture design, not only helping reduce environmental burdens but also promoting healthy lifestyle habits. This study explores the advantages of modular design in enhancing home decoration quality and space utilization efficiency, while integrating elements of traditional culture through design integration.

The significance of this paper is that modular design can enhance the flexibility and diversity of furniture, meet the desire for personalized customization, improve production efficiency and save material costs, promote the sustainable development of the furniture industry, it can also drive the innovation and upgrading of the furniture industry, guide the whole furniture industry to expand in the direction of intelligence and customization.

2. Practice of Sustainable Concept in Modular Furniture Design

2.1 Sustainable Advantages of Modular Design

Modular design breaks down products into independent modules, enabling companies to develop, produce, and test each component simultaneously. This parallel processing approach significantly reduces time-to-market while boosting production efficiency. By allowing reuse of identical modules across different products, it facilitates mass production and lowers manufacturing costs. When automakers adopt modular platforms, they can assemble multiple vehicle models on a single production line, achieving both increased efficiency and reduced expenses.

The modular design significantly enhances product maintainability. With each module featuring independent functional interfaces, businesses can simply replace or repair faulty components without requiring complete system overhauls. This approach not only reduces maintenance costs and downtime but also

minimizes waste generation, contributing to environmental sustainability. The modular architecture enables easy replacement and upgrade of components, thereby extending product lifespan. In smartphones, this design allows convenient replacement of parts like batteries and cameras, further enhancing product durability.

Modular design drives product innovation. The independence of modules makes it easier for enterprises to improve or innovate a specific module without disrupting the normal operation of other modules. Leveraging this flexibility, companies can quickly respond to market demands and launch more competitive products. Lego toy companies adopt modular design approaches to rapidly introduce diverse theme-based Lego building sets that cater to consumers of different ages and interests.

Modular design facilitates sustainable development. By optimizing the combination and configuration of modules, companies can reduce resource waste and enhance product environmental performance. Simultaneously, modular design simplifies product disassembly and recycling, improving resource utilization efficiency. IKEA employs this modular approach in furniture production, allowing consumers to customize and adjust configurations according to their needs. This reduces resource waste and extends the lifespan of furniture products.

In conclusion, modular design has obvious advantages in improving production efficiency, reducing costs, enhancing product maintainability, promoting innovation and achieving sustainable development. These advantages make modular design become a design concept widely concerned by enterprises and designers nowadays, and play a significant role in many fields.

1.2 Environmental Protection Production and Recycling of Modular Furniture

Modular furniture typically prioritizes eco-friendly and renewable materials such as bamboo, recycled wood, and aluminum. These sustainable materials cause minimal environmental impact and are easily recyclable. Some manufacturers even repurpose waste materials like plastic bottles and textile scraps to create furniture components, achieving resource recycling. During production, companies implement energy-saving measures

including clean energy adoption and process optimization. The modular design enhances production flexibility, allowing rapid adjustments to meet market demands while preventing overproduction and inventory buildup, thereby reducing resource waste. Since most materials used in modular furniture are environmentally friendly and renewable, their post-recycling reuse significantly cuts down on pollution from landfills and incineration.

To sum up, the implementation of environmental protection production and recycling of modular furniture is an important way to promote the sustainable development of the furniture industry. By choosing environmentally friendly materials, improving production efficiency, adopting modular design and providing recycling services, the furniture industry can achieve green development.

2. Modular Furniture Design Integration Strategy

2.1 Application of Bamboo Weaving Materials in Modular Furniture

Bamboo offers three key advantages: Firstly, as an eco-friendly material, bamboo is renewable and cost-effective. Bamboo furniture manufacturing avoids heavy chemical use, making it a low-carbon, sustainable choice. Secondly, bamboo naturally retains its original grain patterns and natural hues, creating a soft, warm ambiance that enhances the freshness and natural feel of living spaces. Thirdly, specially treated bamboo products—such as those undergoing hydrothermal carbonization—develop excellent moisture resistance and insect-proof properties, ensuring longer-lasting durability.

With growing environmental awareness and heightened appreciation for traditional culture, bamboo weaving is becoming increasingly prevalent in modular furniture design. When developing modular furniture, bamboo can serve as the primary material for specific components. For instance, bamboo can be used for chair backrests, armrests, or tabletops—elements that not only preserve the natural texture of bamboo but also enhance practical functionality.

To ensure the stability and ease of assembly of modular furniture, it is essential to design appropriate interfaces. For bamboo weaving

materials, physical connections such as mortise-and-tenon joints can be employed, which not only guarantee structural integrity but also allow easy disassembly and reconfiguration. Bamboo processing techniques demonstrate diverse craftsmanship, involving operations like sawing, splitting, cutting, and grinding. During the production phase of modular furniture, selecting suitable processing methods according to specific design requirements is crucial to ensure both reliable quality and an aesthetically pleasing appearance.

2.2 Application of Mortise and Tenon Technology In Modular Furniture

By integrating mortise-and-tenon joints with modular design concepts, modern furniture innovation gains new dimensions. This approach enables designers to create modular components that are both detachable and reassemblable, allowing users to customize configurations according to their needs and spatial layouts. Through simplified and innovative adaptations, these joints now allow effortless assembly for everyday users. By optimizing their geometry and dimensions, designers enhance processing efficiency while maintaining structural integrity. More than just connectors, mortise-and-tenon joints serve as decorative elements themselves. Through strategic layout arrangements, they elevate furniture's artistic appeal and aesthetic appeal, transforming ordinary pieces into functional yet visually striking creations.

For instance, the Timber table (Figure 1) designed by Danish designer Julian Kyhl features dovetail tenon-and-tenon joints for flat panel assembly, while mortise-and-tenon joints connect the tabletop to leg components. This innovative design not only achieves the characteristic flat-pack packaging of the product but also ensures convenient transportation, demonstrating the creative application of mortise-and-tenon joints in modern furniture design.

While mortise-and-tenon craftsmanship demonstrates immense potential in modular furniture, its implementation still faces challenges due to complex techniques, material limitations, and lengthy production cycles. Modern furniture incorporating this traditional technique typically commands higher prices. As technology advances and consumer

appreciation for cultural heritage grows, the application of mortise-and-tenon craftsmanship in modular furniture will become more widespread and sophisticated. Designers must continuously explore and innovate to blend traditional craftsmanship with contemporary design, creating modular furniture products that combine unique charm with practical value.



Figure 1. Example of Modular Furniture Design Using Mortise-and-Tenon Joints — The Timber Table

3. Design Process

The design process of modular furniture design based on the concept of sustainability integrates a number of core links, aiming at the use of innovative design techniques to achieve the ideal combination of environmental protection, practicality and aesthetics of furniture.

Design philosophy serves as the core essence and soul of any design. When creating modular furniture, sustainable principles take center stage, emphasizing resource efficiency and environmental stewardship. This compels me to holistically consider a product's lifecycle from initial design through production, usage, maintenance, and eventual recycling. Designers must also address diverse user needs by adopting modular approaches, enabling furniture to flexibly adapt to various scenarios and spatial configurations.

In the process of design, integrating traditional Chinese elements into furniture design adds unique cultural charm. Traditional Chinese patterns such as plum blossoms, mortise and tenon techniques, along with material elements like bamboo weaving and walnut wood, have been carefully selected and innovatively incorporated into furniture designs. This approach not only preserves the core essence of traditional culture but also aligns with modern aesthetic trends. For instance, in the form design of furniture, one can draw inspiration

from the lines and proportions of traditional furniture to achieve visual harmony. In color coordination, traditional Chinese hues such as natural tones can be employed to create a warm and culturally rich home atmosphere.

Material structure design forms the cornerstone of modular furniture innovation. When selecting materials, environmental sustainability, renewable resources, and recyclability should take precedence. Bamboo and wood exemplify sustainable choices that not only align with eco-friendly principles but also demonstrate exceptional physical properties and workability. Structurally, the design employs mortise-and-tenon joints and modular frameworks to create individualized units. Each component features specialized functions and standardized interfaces, enabling flexible assembly through universal connectors to form diverse configurations. Aesthetically, the designs prioritize fluid lines and minimalist forms, achieving both visual appeal and functional practicality.

Series design serves as a cornerstone of modular furniture innovation. By creating modular units with shared characteristics yet diverse functionalities, users can freely select and combine these components to craft personalized spaces. For instance, transforming tabletops into screens that extend into functional storage cabinets through corner-adjustable mechanisms exemplifies this approach. This strategy not only enhances furniture adaptability and visual versatility but also reduces production and transportation costs, aligning with sustainable development principles.

The modular design is ultimately realized through standardized interfaces and connections (Figure 2). Within modular furniture systems, these components interlock seamlessly to create complete functional units. While each module can stand alone, they also combine to form versatile configurations. For instance, a stool serves as a seating option when used individually, but transforms into a practical shelf when stacked—effectively optimizing spatial efficiency. This approach not only enhances practicality and adaptability but also provides users with extensive customization flexibility.

In conclusion, the modular furniture design integration approach based on sustainable concepts achieves a perfect harmony between

environmental protection, practicality, and aesthetics through multiple aspects such as considering design philosophy, incorporating traditional Chinese elements, optimizing material structure and form, completing series design, and showcasing the characteristics of modular design. This brings a unique experience to modern home living.



Figure 2. Schematic Diagram of Standardized Interfaces and Connection Structure in Modular Furniture

4. Conclusions

The paper thoroughly explores the advantages of modular furniture design, including enhanced flexibility, maintainability, and upgradability, enabling users to adjust and update their furniture according to changing needs. Additionally, it examines the integration of traditional elements like bamboo weaving and mortise-and-tenon joints in modular home design, which helps reduce production and transportation costs while minimizing environmental impact.

Guided by sustainable principles, this paper proposes an integrated strategy for modular furniture design. It emphasizes embedding sustainability throughout the entire design process, prioritizing material selection and circular utilization in manufacturing processes. The study further optimizes inter-module connections and assembly methods while reaffirming the vital role of user participation. By encouraging users to engage in furniture design and customization, the approach aims to fulfill personalized needs, thereby enhancing satisfaction and fostering a sense of belonging. In summary, the modular furniture design integration strategy rooted in sustainable principles has introduced innovative approaches and methodologies to furniture

design, playing a positive role in promoting the industry's sustainable development. By continuously refining design strategies and technical methods, we can achieve more efficient, eco-friendly, and user-centric furniture solutions that create better living environments for people.

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