Green Design Evaluation of Kindergarten Furniture

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Kindergarten is an important place for children's activities, learning, and life, and early childhood is a key basic period of life. In early childhood, young children's organs and body tissues are not mature and have strong plasticity in various aspects such as personality, intelligence, and physical development. Green design is also known as environmental design and environmental awareness design.

kindergarten furniture | green design | analytic hierarchy process (AHP) | gray correlation analysis (GCA)

1. Introduction

Kindergarten is an important place for children's activities, learning, and life, and early childhood is a key basic period of life. In early childhood, young children's organs and body tissues are not mature and have strong plasticity in various aspects such as personality, intelligence, and physical development. However, they are greatly affected by the environment, and the quality of their environment directly affects their physical and mental health and development. The application of green design in kindergarten furniture can create a good living and learning environment for young children, meet the needs of teachers, strive to enable young children to obtain a good education, and enable them to fully develop their intelligence, personality, body, and psychology. Therefore, it is necessary to explore the green design in kindergarten furniture.

Green design is also known as environmental design and environmental awareness design. During the entire life cycle of a product, it is important to consider the environmental attributes of the product (disassemblability, recyclability, maintainability, reusability, etc.) and consider them as design objectives. While meeting the environmental objectives, it is also necessary to ensure that the product meets the functional, service life, quality, and other requirements. The principle of green design is widely recognized as the "3R" principle, namely, "Reduce, Reuse, Recycle"—reducing environmental pollution, reducing energy consumption, and recycling or reusing products and components [1].

The green design emphasizes the satisfaction of the overall space in terms of environmental friendliness, energy conservation, safety, health, convenience, comfort, etc., such as indoor layout, spatial scale, decorative materials, lighting conditions, color configuration, etc., which can meet the physical, psychological, hygienic, safety, health, and other requirements of contemporary society. The basic idea is to incorporate environmental factors and

pollution prevention measures into the entire design process at the design stage, taking environmental performance as the design goal and starting point, and striving to minimize the impact of design results on the environment.

2. Green Furniture Design

The green design adheres to the principle of putting people first, seeking harmony between people and the overall spatial environment, and always based on human behavior, physiology, and psychological characteristics in the design, striving to meet the needs of human beings and achieve optimal benefits in the indoor environment. Green design requires green, environmental friendliness, and energy conservation, mainly referring to the rational and effective use of natural energy. The requirements are beneficial to health, mainly including a non-toxic, pollution-free, and fireproof living environment. It is required to meet the spiritual needs of indoor people, mainly through the appeal of art in design to enable people to obtain spiritual enjoyment [2].

Green furniture has the characteristics of environmental compatibility, prolonging service life, and reflecting innovative ideas [3]. The green design concept can be integrated into the whole process of a product life cycle, from design, manufacturing, use, recycling, and other aspects of implementation one by one, improve the level of furniture design and manufacturing and transform the development of non-green furniture industry, better meet people's consumption demand for green furniture, and achieve a harmonious coexistence between man and nature and the environment.

From the perspective of furniture enterprises, they focus on reflecting their innovative capabilities in green furniture production, thereby improving their competitiveness and obtaining more benefits in the market environment. Bumgardner, M.S. et al. [4] considered emerging and innovative wood design strategies (e.g., bionics) as well as topics that have gained traction in recent years (i.e., green supply chain management and environmental labeling and related marketing communications) to improve the company's competitiveness. Sellitto, M.A. et al. [5] defined how green innovation supports the competitive advantage of an industrial furniture cluster located in southern Brazil by investigating 245 furniture companies in the industrial cluster. The conclusions drawn are green innovation focused on operation and process does not positively influence competitive enablers but influences competitive advantages; green innovation focused on product and customers, and eco-efficiency positively influences the competitive enablers; competitive enablers based only on product and customers and on eco-efficiency positively influences the competitive advantage.

From the perspective of consumers, they focus on the safety and environmental friendliness of furniture. They hope that furniture materials are non-toxic and harmless, and on this basis, consumers will consider aspects such as the design style and symbols of furniture. Barbaritano, M. et al. [6] have investigated how environmental concern affects the relationship between design attributes and purchasing intention. This study concluded that when consumers are highly concerned about environmental issues, they are often more influenced by the symbolic dimension of design. Kwangsawat, K. et al. [7] studied consumers' demand for environmentally friendly furniture,

and the results showed that consumers prefer modern and Western-style furniture, using natural materials for production, high production technology, and cool and moderate furniture.

From the perspective of sustainable design, scholars have optimized the furniture production chain from the perspectives of LCA (Life Cycle Assessment), new environmentally friendly materials, and the decrement principle. Kwangsawat, K. et al. [8] analyzed the differential carbon footprint of each furniture type based on its product life cycle to determine the criteria for selecting low-impact materials for use in desk furniture design. Wang, Y. et al. [9] obtained a waste textile-starch composite material that combines waste textiles, starch, and other components through the use of microwave expansion technology. The material is biodegradable, environmentally friendly, and non-pollution. This study combines sustainable design with composite material manufacturing, effectively solving the problems of textile waste pollution and furniture resources. Wang, Q.W. et al. [10] introduced the properties of wood plastic materials and their applications in furniture manufacturing technology. It was explained that the environmental advantages of wood plastic materials in the future should be fully utilized throughout the entire lifecycle of furniture manufacturing, sales, use, and recycling. Wu, W. et al. [11] discussed the application of the decrement principle in the design of modern mortise and tenon structures under the background of green design, aiming at exploring new ideas of modern mortise and tenon structure design.

3. Kindergarten Furniture Design

Kindergarten furniture has a variety of types, and its distribution is mainly determined by the spatial functions of the kindergarten. Kindergartens both at home and abroad include functional spaces such as natural areas, manual areas, language areas, science areas, book reading areas, art areas, music areas, structural activity areas, and social activity areas, but there are significant differences in their spatial patterns.

Currently, most domestic kindergartens continue to use a spatial pattern that integrates activity rooms, bedrooms, bathrooms, and clothing storage rooms, emphasizing the independence of each class to ensure that they do not interfere with each other and do not interact with each other. With the progress and development of children's physiology and psychology, it has been found that most of their thinking is obtained through direct action and perception, while this fixed and rigid spatial pattern ignores children's physiological and psychological characteristics, often limiting the development of children's personality, impeding the development of intelligence and children's communicative abilities. Furniture should provide children with forms that adapt to their needs and preferences [12]. Different from the domestic teaching model, foreign kindergartens have separate activity rooms in each class. The corners of their activity rooms are rich in content and diverse in activities. The toilets, wash basins, and cloakrooms are collectively shared, and the original corridor route has been transformed into a multi-functional hall and greenhouse space for collective activities, changing the traditional rigid pattern and becoming a comprehensive activity space for children to communicate, play, and interact.

Current research on the design of kindergarten furniture has mainly focused on the impact of the size and function of kindergarten furniture design on the learning ability and health of preschool children. Iliev, B. et al. [13] proposed suggestions to better adapt the chair size to children's body size by measuring the body size of preschool children

and comparing it with the chair size of kindergartens in three regions. Giraldi, L. et al. [14] optimized furniture, products, and graphics in preschool environments from the perspective of real attitudes, emotions, and abilities in children's lives, and proposed a set of good practices suitable for kindergarten environments, effectively improving children's educational experience. Gimenez, R. et al. [15] investigated the role of two different layouts of school furniture in the pattern legibility and spatial-temporal parameters of graphic skill acquisition. Research has found that adjustable desks facilitate the acquisition of clear graphic patterns and can enhance children's handwriting and drawing skills.

4. Green Design Evaluation

The life cycle assessment (LCA) is a systematic method for assessing the potential environmental impact of a product, process, or activity throughout its life cycle from resource collection, manufacturing, and use stage to disposal. It aims to comprehensively analyze and evaluate the environmental performance of different products or services to help make more sustainable decisions [16]. Bianco, I. et al. [17] have developed a life cycle assessment (LCA)-based tool that considers the main materials and processes typically used in the furniture sector. The tool has made it possible to quantify the environmental impacts of the armchair and the evaluation of four possible scenarios to enhance its environmental sustainability. This work can therefore guide the actors in furniture value chains as to the choice of the criteria able to maximize furniture sustainability throughout its life cycle. Mohd Azman, M.A.H., et al. [18] have performed a cradle-to-gate life cycle assessment (LCA) of particleboard production by using OpenLCA 1.10.3 Windows software, and the conclusion shows that particleboard has a minimal impact on the environment, except for global warming. Lv, H. et al. [19] used the life cycle assessment method to collect and calculate the material and energy consumption of oak in various stages from timber harvesting, transportation, and wood production to drying and used SimaPro 8.0.1 software to carry out an environmental impact assessment. The results showed that the environmental impact of oak-sawn timber is mainly reflected in the emission of respiratory inorganic substances and fossil fuel consumption.

To identify environmental criteria for evaluating and selecting green suppliers for the furniture industry, Dos Santos, B.M. et al. [20] proposed a methodology that uses a hybrid entropy-TOPSIS-F framework to weigh the criteria and select the supplier with the best environmental performance. The fuzzy approach is integrated with Shannon's Entropy and TOPSIS methods to deal with uncertainty in the decision-making process. Zhang, Y. et al. [21] combined gray correlation analysis (GCA) to establish a cost-benefit evaluation model and select power transformers based on life cycle cost (LCC). Guo, J. et al. [22] combined the characteristics of green products, proposed an evaluation method of mechanical and electrical products green design based on an analytic hierarchy process, and established the evaluation steps of green design. Pu, Y. et al. [23] used the method integrating GCA with the analytic hierarchy process (AHP) to solve the problem of lightweight material selection for a car body, and a case study is applied to verify the practicability of the proposed approach.

In the context of countries working together to tackle climate change and promote green and low-carbon development, more and more attention is paid to the carbon footprint of suppliers. Huang, F. et al. [24] filled this gap by incorporating carbon emission criteria into supplier selection and presenting a method of combining the Fuzzy

analytic hierarchy process (FAHP) and Fuzzy goal programming (GP) to address the problem of supplier selection and order quota allocation. Lin, R.J. et al. [25] used fuzzy set theory and the method of decision test and evaluation laboratory to form a structural model and find out the causal relationship between the criteria to optimize green supply chain management.

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