

A Study on the Design of Multifunctional Storage Furniture for Children Based on a Modular Structure

Songchen Li¹, Sangyun Han^{2*}

Abstract

As family lifestyles and children's developmental needs continue to change, children's storage furniture has shifted from a simple storage tool to a product that supports organization, spatial planning, and growth adaptability. However, existing products remain largely based on fixed structures and preset functions, showing limitations in height adjustment, functional transformation, spatial combination, and children's autonomous participation. This study examines storage furniture for children aged 3 to 6 in home environments. Based on literature analysis, case analysis, and a user needs survey, it identifies problems in terms of structure, function, use, and modular characteristics, and translates user needs into design principles. It then proposes a multifunctional storage furniture design centered on modular units, a unified connection logic, functional module replacement, and phased combinations. The results show that modular structures can improve the adaptability of children's storage furniture to children's developmental changes and spatial conditions in home environments. This study provides a design reference for developing growth-adaptive children's storage furniture in home environments.

Keyword : Children's Storage, Modular Structure, User Participation, Growth Adaptability

1. Introduction

1.1 Research Background and Objectives

In family life, children's storage behavior involves taking out, organizing, and returning toys, picture books, stationery, and daily necessities. It is closely related not only to object management but also to children's spatial cognition, sense of order, and autonomous behavior. Therefore, children's storage furniture should support both storage functions and children's active participation.

Children aged 3 to 6 experience rapid changes in body dimensions, cognitive abilities, and behavioral habits, while the types of objects they use and their storage methods also change with age. However,

1 Department of Convergence Industrial Design, Hanseo University, Seosan, Korea [Ph.D. Student]

e-mail: lee.s.s9818@gmail.com

2 Department of Convergence Industrial Design, Hanseo University, Seosan, Korea [Professor]

e-mail: han1469@hanseo.ac.kr (Corresponding author)

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most existing children's storage furniture is based on fixed structures and preset functions, showing limitations in height adjustment, functional transformation, spatial combination, and children's autonomous participation.

Accordingly, this study focuses on storage furniture used by children aged 3 to 6 in home environments. It explores the application of modular structures to multifunctional storage furniture for children and proposes a design solution that can adapt to children's growth-related changes and diverse usage needs.

1.2 Research Method and Scope

This study focuses on the relationship between the usage behaviors of children aged 3 to 6 in home environments and the structure of children's multifunctional storage furniture, with the research scope limited to children's storage furniture used in home environments in order to maintain consistency in the usage context. The research methods include literature analysis, case analysis, and a user survey, in which literature analysis examines the relationship between children's developmental characteristics and storage behavior, case analysis identifies the limitations of existing products in terms of growth adaptability, and the user survey verifies related problems and needs in actual use.

2. Theoretical Analysis

2.1 Children's Developmental Characteristics and Storage Furniture Needs

Children aged 3 to 6 experience rapid changes in physical development, cognitive abilities, and behavioral patterns. Their use of furniture is often accompanied by exploration, play, and repeated operation. Cognitive flexibility in early childhood supports children's adaptation to environmental changes, creative exploration, orderly behavior, and autonomous learning [1]. Therefore, children's furniture should be understood not only as a functional object, but also as a factor that influences children's daily behaviors and living habits.

From the perspective of storage behavior, children's object use changes with age. Younger children mainly use toys and picture books, and their storage behavior is mostly expressed as simple taking out and putting back. As they grow older, drawing materials, craft supplies, and simple learning materials increase, leading to greater needs for classification and organization. Flexible furniture layouts can enhance children's autonomous exploration and social interaction in space [2], suggesting that children's

storage furniture should respond to changes in object types and use behaviors.

Children's storage furniture should also consider body dimensions, operational ability, and home activity contexts. Furniture that is too high, too deep, or difficult to operate may reduce children's willingness to use it independently, while appropriate dimensions, clear operation paths, and intuitive classification methods can support autonomous behavior. Since around the age of three is an important period for the development of rule-switching and behavioral adjustment abilities [3], multifunctional storage furniture for children aged 3 to 6 should respond to changes in physical, cognitive, and behavioral characteristics. Children's storage furniture should accommodate age-related developmental needs and support independent access, organization, and storage, while also considering children's play and learning activities [4]. These requirements provide a theoretical basis for applying modular structures to multifunctional storage furniture for children.

2.2 Modular Design and the Adaptability of Children's Storage Furniture

Modular design is a design method that divides a product into relatively independent units and enables combination, replacement, and expansion through unified module dimensions and connection logic. In product design research, modular structures are regarded as an important way to improve the flexibility of product function configuration and structural organization, allowing products to be adjusted and reorganized according to different user needs [5]. Therefore, the focus of modular design is not merely formal combination, but the improvement of product variability and long-term use value through the systematic relationship among modular units, connection methods, and functional configurations.

In children's storage furniture, modular structures are closely related to growth adaptability. The body dimensions, object types, usage behaviors, and home spatial conditions of children aged 3 to 6 change continuously as they grow. Fixed storage furniture can easily lead to unsuitable height, insufficient capacity, limited functions, and restricted spatial combination. In contrast, modular structures can respond to children's usage needs at different growth stages through module addition and removal, position adjustment, and functional module replacement.

Clear modular relationships and simplified combination methods can also reduce operational difficulty and enhance children's autonomous participation in taking out, organizing, and using furniture. Related studies have indicated that modular combinations can improve the adaptability of children's furniture to changes in behavior and spatial use needs [6]. Therefore, modular design provides design approaches for structural reorganization, functional transformation, children's autonomous participation, and spatial adaptation in multifunctional storage furniture for children, and offers a theoretical basis for the

subsequent analytical framework.

2.3 Analytical Dimensions of Children's Storage Furniture

The previous analysis shows that children aged 3 to 6 undergo continuous changes in body dimensions, cognitive abilities, behavioral patterns, object use needs, and home spatial conditions. These changes require children's storage furniture to respond in terms of structural form, functional configuration, operation method, and spatial adaptability. At the same time, modular design provides possibilities for structural reorganization, functional transformation, and spatial adaptation. Based on children's developmental characteristics and modular design, this study constructs analytical dimensions from four aspects: structure, function, use, and modular characteristics. These dimensions are used as evaluation criteria for the subsequent case comparison and design transformation, as shown in [Table 1].

[Table 1] Analytical Dimensions

Dimension	Main Contents	Evaluation Focus
Structural dimension	Furniture scale, spatial organization, and structural form	Whether it corresponds to children's body dimensions and allows easy reach and operation
Functional dimension	Storage objects and functional configuration	Whether it adapts to different types of objects and provides functional transformability
Use dimension	Operation methods and interaction logic	Whether operation is intuitive and safe, and whether it promotes children's autonomous participation in storage
Modular characteristic dimension	Module combination and structural adjustment methods	Whether it has combination and expansion capabilities and supports growth adaptability

3. Analysis of Children's Storage Furniture and User Needs

3.1 Current Status and Type Characteristics of Children's Storage Furniture

From the perspective of current market development, children's storage furniture shows relatively stable typological characteristics in structural form, storage method, and spatial organization. Based on existing product forms and use patterns, this study classifies children's storage furniture into three types: open shelves and grid cabinets, box and drawer storage, and composite space-utilization storage. Open shelves and grid cabinets emphasize low-position access and visual storage, as shown in [Table 2]. Box and drawer storage focuses on capacity and centralized storage, as shown in [Table 3]. Composite

space-utilization storage integrates storage with beds, walls, or learning areas to improve home space efficiency and support functions such as display, reading, and learning support, as shown in [Table 4].

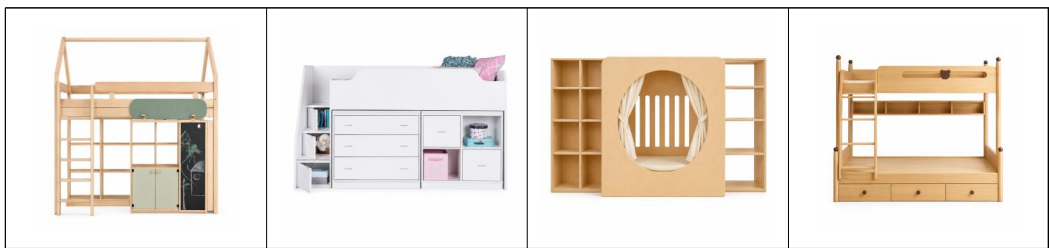
[Table 2] Examples of Open Shelves and Grid Cabinets



[Table 3] Examples of Box and Drawer Storage



[Table 4] Examples of Composite Space-utilization Storage



Overall, existing children’s storage furniture shows development trends toward lower height, openness, and spatial integration, but still has limitations in growth adaptability and functional transformability. Therefore, the subsequent case analysis focuses on structural adaptability, functional transformability, ease of use, and modular expandability.

3.2 Case Analysis and Problem Identification of Children’s Storage Furniture

The previous classification summarizes children’s storage furniture in terms of structural form, storage method, and spatial organization, but it does not sufficiently explain the design logic and problems of

different products in actual use. Therefore, this study selects representative cases for comparative analysis based on market representativeness, structural differences, relevance to children's use, and modular characteristics. Since box and drawer storage is widely used in the market and includes different structural forms such as frame-insertion and stacking-nesting structures, TROFAST and MUJI are selected as comparative cases. The selected cases are shown in [Table 5].

[Table 5] Cases of Children's Storage Furniture

Case	Image	Structural Form	Characteristics
TROFAST		1. Frame-type structure 2. Insertable storage boxes	1. Clear classification 2. Flexible combination
MUJI		1. Stacking 2. Nesting structure	1. Unified scale 2. Stacking expansion
Oeuf Mini Library		Open shelf structure	1. Low and safe 2. Easy access
Flexa		Composite combination structure (bed + cabinet + desk)	1. Functional integration 2. Systematic combination

To improve the systematic nature of the case analysis, this study evaluates the selected cases from four aspects based on the analytical dimensions established above: structural adaptability, functional transformability, ease of use, and modular expandability. The results are presented using symbols, where “●” indicates strong performance, “◐” indicates relatively good performance, “◑” indicates average performance, and “○” indicates weak performance. The evaluation results are shown in [Table 6].

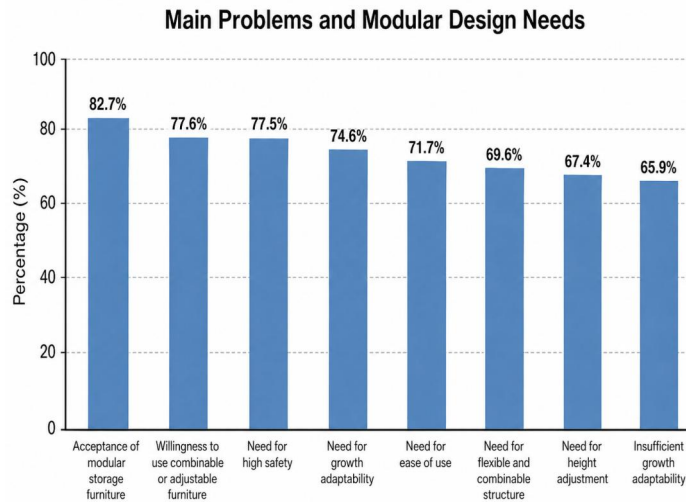
[Table 6] Evaluation Results of Selected Cases

Case	Structural Adaptability	Functional Transformability	Ease of Use	Modular Expandability	Radar Chart
TROFAST	⊙	⊙	●	⊙	
MUJI	◐	⊙	⊙	◐	
Oeuf Mini Library	●	◐	●	○	
Flexa	⊙	●	◐	⊙	

The case comparison shows that although existing children's storage furniture differs in structural form, functional organization, and use patterns, common limitations remain in long-term home use. Structurally, fixed frameworks and limited adjustability make it difficult to respond to changes in children's body dimensions, object types, and use patterns. Functionally, multiple functions are often arranged in parallel without effective transformation mechanisms. In terms of use, adult-oriented zoning logic and operation methods restrict children's autonomous participation in storage. In terms of modularity, module standards, connection methods, and expansion logic remain insufficiently systematic. These limitations in structural adaptability, functional transformability, ease of use, and modular expandability provide the basis for subsequent design optimization.

3.3 User Needs Survey and Use Behavior Analysis

A total of 300 questionnaires were distributed, and 276 valid responses were collected. The results show that most respondents were parents (84.1%, n=232), followed by grandparents (10.1%, n=28) and other guardians (5.8%, n=16). The children were aged 3 to 6 years. Children aged 3 years accounted for 23.2% (n=64), those aged 4 years for 25.4% (n=70), those aged 5 years for 26.8% (n=74), and those aged 6 years for 24.6% (n=68), showing a relatively balanced distribution. In addition, all participating households were currently using children's storage furniture (100%, n=276), indicating that the sample had practical use experience and could provide a reliable basis for the subsequent analysis.



[Fig. 1] Main Problems and Modular Design Needs

The survey results further indicate that existing children's storage furniture does not sufficiently respond to children's growth related changes, and its fixed structure limits adjustment, recombination, and flexible spatial use. Users also showed clear demand for storage furniture that is safer, easier to use, adjustable, and capable of modular expansion. The key problems and modular design needs are summarized in [Fig. 1]. These results provide a basis for introducing modular design into children's storage furniture.

Based on the key questionnaire results, this study summarizes the relationship between user problems, needs, and design directions according to the analytical dimensions established above, as shown in [Table 7].

[Table 7] Summary of User Needs and Design Directions

Analytical Dimension	Survey Problem	User Needs	Design Direction
Structural dimension	Fixed structure and low growth adaptability	Adjustable and reconfigurable structure	Modular structure system
Functional dimension	Single function and demand for functional transformation	Multifunctional integration and transformation	Functional module design
Use dimension	Inconvenient use and low children's autonomous participation	Simple operation and enhanced autonomous participation	User behavior-oriented design
Modular characteristic dimension	Low spatial flexibility and high demand for expansion	Flexibility and expandability	Module combination and expansion

4. Design Strategy and Proposal Based on a Modular Structure

4.1 Design Needs and Principles

Since the research subject of this study is children's storage furniture used in home environments, related standards and anthropometric data are not directly applied as fixed specifications. Instead, they are used as references for setting the tabletop activity module, storage module height, operation position, and combination levels. The related references and design application directions are shown in [Table 8].

[Table 8] Design Basis and Dimensional Derivation

Analysis Item	Children's Desk and Chair Height References	Children's Growth Data	Children's Body Dimension Data	User Needs Data
Data source	KS G 2010 [7], GB/T 3976-2014 [8], BS EN 1729 [9]	WS/T 423-2022 [10], 2017 Korean National Growth Charts [11]	Size Korea [12]	Questionnaire survey
Data type	Reference standards for children's desk and chair dimensions	References for children's height and growth	Survey data on children's body dimensions	Empirical user needs
Extracted content	Relationships among tabletop height, seat height, and body height	Height ranges and body dimension changes of children aged 3 to 6	Body height, sitting dimensions, and ergonomic data	Growth adaptability, fixed structure, and functional and spatial problems
Application direction	Cushion and tabletop activity functions	Module height and phased height adjustment	Reach height, sitting posture, and storage levels	Modular design, height adjustment, and spatial combination

Based on the related data, the height ranges of children aged 3 to 4, 4 to 5, and 5 to 6 are approximately 89.7 - 110.2 cm, 96.5 - 117.9 cm, and 103.0 - 132.5 cm, respectively. The corresponding tabletop height ranges are 400 - 460 mm, 400 - 490 mm, and 430 - 520 mm, while the seat height ranges are 210 - 250 mm, 210 - 270 mm, and 230 - 290 mm. Based on this analysis, user needs are further translated into design principles and implementation paths, as shown in [Table 9].

[Table 9] Transformation Matrix from User Needs to Design Principles

Dimension	Main Problem	User Needs	Transformation Method	Design Principle
Structure	Fixed structure and low growth adaptability	Adjustable and reconfigurable structure	Basic modules and height extension modules	Growth-adaptive modular structure
Function	Single function and low functional transformation	Multifunctional integration and transformation	Module combination and functional module replacement	Functional integration
Use	Inconvenient use and low autonomous participation	Simple operation and enhanced participation	Low-position operation and visualized classification	Children's autonomous participation
Modularity	Low spatial flexibility	Flexible combination and phased expansion	Horizontal combination, vertical stacking, and phased expansion	Flexible combination for home spaces

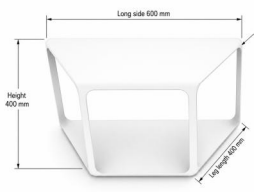
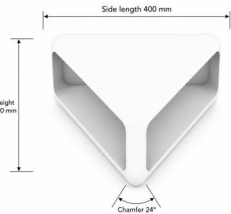
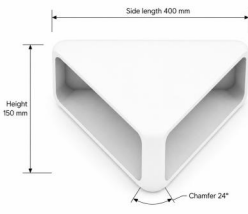
4.2 Construction of the Modular Structure System

Through the nested relationship between the trapezoidal main body and the two embedded triangular modules, the design enables functional transformation among storage, seating, tabletop activities, and combined configurations, as shown in [Table 10].

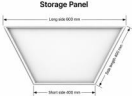
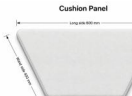
The extension modules are auxiliary components used with the main module to support height adjustment, functional supplementation, and combination expansion, as shown in [Table 11].

To explain how the modular system transforms under different use conditions, this study summarizes the combination relationships among the main module, embedded triangular modules, and extension modules into two types, as shown in [Table 12].

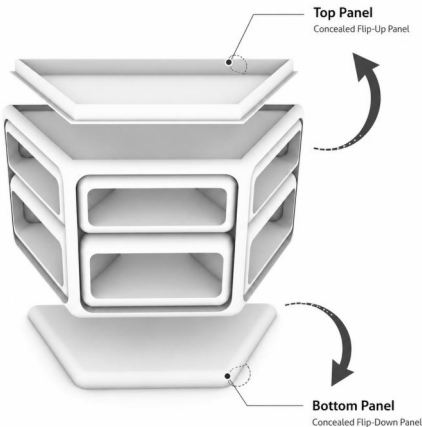
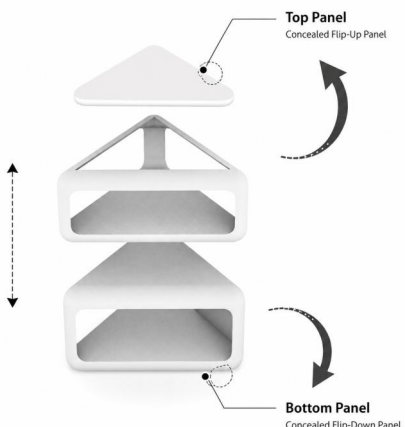
[Table 10] Composition of Main Modules

Trapezoidal Main Storage Module	Embedded Triangular Module 1	Embedded Triangular Module 2
		
Main storage and tabletop support	Low-position cushion and auxiliary support	Secondary cushion and height support
Forms the basic storage space and accommodates two embedded triangular modules.	Can be embedded in or removed from the main module for cushion or support use.	Can be embedded with Module 1 to supplement cushion height and support function.

[Table 11] Composition of Extension Modules

Extension Module 1	Extension Module 2	Extension Module 3	Extension Module 4	Extension Module 5
				
Height Extension Module	Trapezoidal Cushion Panel Module	Blackboard Panel Module	Perforated Panel Module	Triangular Cushion Panel Module
Height adjustment and tabletop zoning	Replacement with the height extension module	Drawing, writing, and interaction	Replacement with the blackboard panel module; display, hanging, and classified storage	Functional support for triangular cushion use

[Table 12] Module Combination and Expansion Methods

Expansion Method 1	Expansion Method 2
	
The trapezoidal main module and embedded triangular modules form the basic use state, while reversible hidden extension modules are arranged in the upper and lower parts.	Different support heights are formed by stacking the embedded triangular modules, adapting to changes in storage levels and cushion height.

4.3 Growth-Stage Adaptation of Modular Configurations

To respond to changes in body dimensions, storage behavior, and usage needs among children aged 3 to 6, this study divides the module combinations into three adaptation stages: ages 3 to 4, 4 to 5, and 5 to 6. Different module combinations are used to gradually expand storage, seating, and tabletop

activity functions, as shown in [Table 13].

[Table 13] Age-Based Adaptation of Module Combinations

Age Stage	Combination Diagram		Adaptation Focus
3 to 4			Low-position access and basic storage
4 to 5			Height adjustment and book storage
5 to 6			Zonal organization and composite use

This table presents staged adaptations of module combinations according to changes in object types, use behaviors, and activity needs among children aged 3 to 6. For ages 3 to 4, low-position open storage supports toy access and basic organization. For ages 4 to 5, module stacking and spatial expansion respond to storage needs involving picture books, books, and toys. For ages 5 to 6, composite combinations and functional panel expansion support classified organization, learning support, and multiple use scenarios. In this way, the module combination plan gradually expands from basic storage to composite use.

5. Conclusion

The results of this study show that fixed structures are a major reason why current children’s storage furniture has difficulty adapting to the growth-related changes of children aged 3 to 6. As children’s body dimensions, object types, and use behaviors continue to change, existing products often present

problems such as unsuitable height, insufficient functional transformation, limited spatial combination, and low children's autonomous participation. Therefore, the design of children's storage furniture should move beyond a single storage function toward a systematic design that supports structural adjustment, functional transformation, and children's autonomous participation.

Modular structures provide an effective design direction for addressing these problems. This study proposes a multifunctional storage furniture design for children centered on a trapezoidal main module, embedded triangular modules, and extension modules. Through nesting, replacement, and stacking among modules, the design enables functional transformation among storage, seating, display, and tabletop activities, and can be adjusted according to different growth stages and home spatial conditions.

Accordingly, the value of modular structures in children's storage furniture design is mainly reflected in three aspects: growth adaptability, functional integration, and continuous use of space. This study provides a reference for the development of children's storage furniture from fixed products toward adjustable, expandable, and multifunctional systems. However, this study mainly focuses on the construction of a design proposal. This study provides a design reference for transforming children's storage furniture from fixed single-function products into adjustable, expandable, and multifunctional modular systems.

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