

Research on the Hybrid Design of Children's Toys and Stationery for Sustainable Consumption

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Abstract: In order to cope with the common functional fragmentation, short product lifespan and serious waste of resources in children's stationery and toys, this study proposes a sustainable design method for children's products through SnapPen designed by the author. SnapPen is a hybrid product that integrates watercolor pens and blocks. The study combines the principle of circular economy with product lifespan extension strategies to promote sustainable consumption. By integrating user behavior analysis, modular structure design and material sustainability evaluation, the study establishes a design framework centered on functional transformation, emotional attachment and recycling. Design practice shows that the hybrid design strategy can not only realize multi-functional use to extend the physical lifespan of the product, but also strengthen the emotional bond through the active participation of children in the assembly and conversion process, thus greatly reducing the intention of discarding. This article systematically discusses the concept of sustainable design, existing problems, design strategies and practical verification, and provides an applicable reference model for the sustainable design of children's products.

Keywords: Sustainable Consumption; Hybrid Design; Children's Product Design; Lifespan Extension; Modular Design; Design Strategies.

1. Introduction

With the global popularization of sustainable consumption, extending the lifespan of children's products has become an urgent design challenge. Although children's stationery and toys are the core of daily life, they traditionally have separate functions - utilitarian and entertainment - resulting in short product life and a lot of waste. Plastic accounts for more than 90% of the toy market, but with the decline of children's interest, most toys have been discarded. Similarly, single-function stationery usually does not attract children, resulting in early disposal. Given that children's consumption behavior is formative, the design strategy of hybridizing stationery and toys can expand product use while improving environmental awareness. This study takes SnapPen, a watercolor pen that can be converted into blocks, designed by the author, as a case study. It draws on circular economy theory and lifespan extension strategies to propose and verify the design method of hybrid children's products and provide insights for sustainable design practices.

2. Overview of Sustainable Design Concepts and Research Trends in China and Abroad

2.1. Core Connotations of Sustainable Design and Its Extension in the Field of Children's Products

Sustainable design emphasizes environmental, economic and social balance throughout the product life cycle. Its fundamental goal is to meet the current needs without affecting the ability of future generations to meet their own needs. Within the framework of the United Nations Sustainable Development Goals, Sustainable Development Goal 12 (Responsible Consumption and Production), Sustainable Development Goal 9 (Industry, Innovation and Infrastructure) and Sustainable Development Goal 3 (Good

Health and Well-being) are all directly related to sustainable product design. In the context of children's products, the uniqueness of sustainable design is that users are in the stage of rapid development; therefore, products must meet the requirements related to safety, functional adaptability and behavior guidance at the same time. Therefore, children's sustainable design goes beyond the protection of materials and energy, and places more emphasis on cultivating consumption habits related to resource conservation, reuse and appreciation of property through design intervention. This means that product design should meet the changing developmental needs of children, while maximizing product longevity and minimizing unnecessary functional iteration and resource consumption.

2.2. International Research Trends in Sustainable Consumption and Hybrid Product Design

Since the end of the 20th century, sustainable consumption has shifted from policy to product design. The European Union pioneered the eco-labeling of children's products, while Western scholars established a framework for life extension and modular design. Recent hybrid design studies show that structural sustainability has been fully considered, but material sustainability is still lacking. Research shows that although the consumer behavior gap still exists, modular and adaptive toys have been developed. The Tarnur plywood system reflects the circular design through tool-free assembly and reconfigurability.

2.3. Comparison of Domestic and International Research and the Research Focus of This Study

The comparison of domestic and foreign studies shows that overseas research is more mature in sustainable design theory, product life cycle evaluation and hybrid product design methods, and has established a relatively comprehensive

theoretical framework and evaluation tools. In recent years, international studies have increasingly emphasized the integration of behavioral science into sustainable consumption research. In contrast, China has shown strong post-development advantages in policy support and industrial transformation; however, there is still a significant gap in the development and actual verification of specific hybrid design strategies for children's products.

At present, integrating the functions of stationery and toys to achieve the goal of prolonging product life and sustainable consumption has become a forward-looking research direction. Taking this point of view as the starting point, this study adopts the self-designed SnapPen watercolor pen building block product as a case study to systematically build a hybrid design strategy for children's stationery and toys for sustainable consumption, focusing on functional conversion mechanisms, modular structure design, sustainable material selection and user behavior guidance.

3. Current Status and Challenges in the Design of Children's Stationery and Toys

3.1. Functional Distribution and Usage Characteristics of Children's Stationery and Toy Products

In the current market, children's stationery products are mainly used for practical purposes such as writing, painting and recording. Their design mainly emphasizes operational efficiency, grip comfort and adaptability to learning scenarios. In contrast, toys focus on entertainment, imagination games and role-playing experiences, and pay more attention to interaction, enjoyment and creativity. Therefore, these two categories have long been separated in terms of design concept, material selection, structural form and production standards.

Table 1. Competitor Analysis Table

Product Type	Representative Brands/Products	Core Function	Sustainability	Reference Images
Traditional Stationery	M&G collaborative series (SpongeBob SquarePants, One Piece, etc.)	Writing and Drawing	Low (Single-Use Consumption)	
Traditional Toys	LEGO building blocks	Assembly and Construction	Medium (Reusable)	
Superficially Integrated Products	DAISO × Sanrio Collaborative Stationery	Stationery with IP-based Cartoon Aesthetics	Low	
Modular Stationery	DareWorks Assembly Pen Series	Writing with Customizable Modular Assembly	Medium (Single-Material Recyclability)	
Sustainable Toys	Green Toys (Made from recycled milk bottles)	Pure Toy Functionality	High (100% Recycled Plastic)	
Emotional Cultural and Creative Products	Sailong Stationery / Never	Writing Combined with Emotional value and IP Collaborations	Medium (Carbon Footprint Certified)	

In recent years, some brands have tried to integrate cartoon images or playful color schemes into stationery products, or embed simple writing and painting functions into toys. However, at the aesthetic level, these attempts are largely superficial combinations and lack in-depth integration at the

functional and structural levels. For example, the assembly-based pen series launched by the Dareworks brand adopts a modular design method; however, writing is still its core function, and the block structure is mainly used for personalized appearance customization, not function

conversion. This superficial integration makes it difficult to achieve meaningful product lifespan extension, and it cannot effectively guide children to achieve sustainable consumption behaviors.

From the point of view of material usage, traditional plastic toys often contain chemical additives, some of which may pose a risk to children's health and have a negative impact on the environment. Similarly, stationery products rely heavily on disposable plastic components, which further aggravates resource consumption and waste generation.

3.2. Functional Fragmentation and the Intensification of Design Resource Waste

Functional fragmentation limits the use of stationery for educational purposes and toys for games, resulting in low utilization. The change in children's interests has promoted the rapid discarding of single-function products and strengthened the linear consumption pattern. Research shows that toys are usually replaced before they run out of function due to the lack of safe and sustainable materials. Low-value and hard-to-recycle products lack recycling mechanisms, and reused toys may expose children to hazardous chemicals, which contradicts the principle of sustainable consumption.

4. Sustainable Design Principles for Children's Stationery and Toys

4.1. Goal Level: Extending Product Lifespan

Product lifespan is a multi-dimensional concept, including technical life (physical function limit), service life (actual use time), replacement life (purchase to replacement period) and economic life (cost-based replacement threshold) (Cooper, 2010). Extending product life refers to a design strategy aimed at extending this period by improving durability, adaptability and user participation. In children's stationery and toy design, product life extension is operated through durability, adaptability and user participation. Improve durability through structural and material robustness; improve adaptability through modular and replaceable components; enhance user engagement through interactive and growth-oriented design functions, which support continuous use across development stages.



Figure 1. Tripp Trapp Growth Chair. Image source: STOKKE official website

The Tripp Trapp chair, designed by Norwegian designer Peter Opsvik, is a landmark example of this principle. With its adjustable seat and foot pedal structure, this chair can accommodate users from babies to adults. It shows that the

structural adaptability in the design can effectively extend the life of the product several times or even more than ten years, thus fundamentally reducing the waste of resources associated with furniture replacement.

4.2. Resource Level: Promoting Application of Sustainable Materials

Material selection is a key component of sustainable design. The environmental impact of a product is largely determined by decisions made during the design phase, requiring life-cycle assessment across extraction, manufacturing, use, and disposal (Ashby, 2013).

In children's stationery and toy design, the application of sustainable materials plays an important role in reducing environmental impact and ensuring product safety. Sustainable materials such as bio-based plastics, recycled plastics and natural fiber materials are increasingly used because they reduce the ecological burden and improve the recyclability at the end of the life cycle. In addition, in this case, the material selection must comply with strict safety requirements and avoid harmful substances such as heavy metals and toxic additives to ensure the safe use of children.

Take Green Toys, an American environmental protection toy brand, as an example. Its products are mainly made of high-density polyethylene from recycled milk bottles. This method can not only reuse wasted resources, but also avoid the use of harmful substances such as bisphenol A (BPA) and polyvinyl chloride (PVC) in the manufacturing process. This case reflects the organic integration of environmental sustainability and child safety, and represents a typical model of sustainable material application.

4.3. Structural Level: Applying Modular Design

Modular design is one of the effective ways to achieve product sustainability. A module refers to a grouping of components that share similar life-cycle processes and are independent from components outside the module (Gershenson et al., 2003).

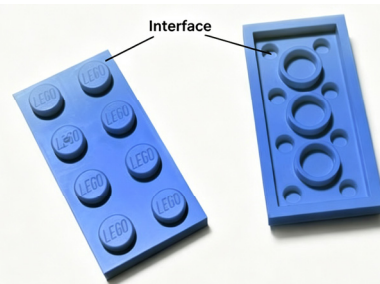


Figure 2. LEGO bricks. Image source: Author's own illustration.

In the design of children's stationery and toys, modular design not only extends the life of products, but also enhances the fun and educational value. Specifically, the removable structural design allows the replacement of damaged components; the modular combination can achieve diversified functional configurations; the introduction of scalable modules provides continuous upgradeability across different stages, thus prolonging the participation and interest cycle of children.

Lego is a representative example of modular design. Based on its core "screw wood and tube" coupling system, Lego has established a universal connection standard. Regardless of size or function, all modules can be seamlessly interconnected.

This high compatibility makes it possible to reorganize new and old components, effectively preventing product disposal caused by the outdated functions of individual toys.

5. Sustainable Design Practice for Children's Stationery and Toys: A Case Study of SnapPen

5.1. Product Design Positioning and User Research

SnapPen is a sustainable hybrid product that integrates stationery and toy functions, specially designed for children's use. Its core positioning is between learning tools and fun-based media. This product uses watercolor pens as its main

carrier. While maintaining basic writing and drawing functions, it combines a structural design that can be assembled and reconfigured, transforming it from a single-function tool to an open product with multiple usage modes. The design aims to solve the problem of functional monotony and short life in traditional children's stationery and toys, thus proposing a sustainable design method based on the combination of functions.

This survey aims to investigate the behavior patterns of children aged 3-10 in using stationery and toys, as well as parents' acceptance of sustainable design products, and provide data support for the optimization of SnapPen. The online questionnaire survey method was carried out, and 121 valid replies were produced. The respondents are the parents or main caregivers of children aged 3-10.

Table 2. Cross-analysis of Children's Age and Product Replacement Frequency (N=121)

Age of Children	Sample Size	Watercolor Pen Replacement Frequency (%)			
		Within 1 month	1-3 months	3-6 months	More than 6 months
Ages 3-4	22	22.7	45.5	22.7	9.1
Ages 5-6	42	16.7	42.9	28.6	11.9
Ages 7-8	34	11.8	41.2	32.4	14.7
Ages 9-10 and older	23	8.7	34.8	30.4	26.1

Table 2 shows the difference in the replacement frequency of children's watercolor pens in different age groups. Data shows that young children change watercolor pens more frequently.

Specifically, in the 3-4-year-old age group, 22.7% of the respondents said that they had changed their watercolor pen within a month, which is significantly higher than the 8.7% of the 9-10-year-old and above age group. At the same time, 26.1% of the respondents in the 9-10 and above age group reported that they changed the pen after more than six months, much higher than 9.1% of the 3-4-year-old age group.

This trend may be attributed to two main factors. First of all, young children have not fully developed fine movement control in writing and painting activities, which makes them more likely to damage the pen tip, lose the pen cap or overuse, all of which will accelerate product degradation. Secondly, young children tend to experience a faster change in interests and have low continued participation in single-function products.

These findings show that product designs for young children (3-6 years old) should place more emphasis on structural durability and lasting appeal. Through functional integration and modular reconfiguration strategy, SnapPen can effectively extend its service life in this age group.

Table 3. Acceptance of Modular Design (N=121)

Attitude	Number	Percentage (%)
Strongly Support	35	28.9
Moderately Support	57	47.1
Neutral/Do Not Support	29	24.0

Table 3 shows parents' attitudes towards modular design and their perceived value judgment. In terms of attitude, 76.0% of parents expressed "strong support" or "moderate support" for modular design, while only 24.0% held a neutral or negative view. This result shows that modular design - a product architecture strategy characterized by disassembly,

reconfiguration and scalability - has a relatively strong user acceptance base in the field of children's products. These results provide two key implications for the design of SnapPen. First of all, the modular structure is not only a technical means to achieve product sustainability, but also a design strategy to improve the added value of product education. Secondly, in product communication and marketing, the role of modular design in cultivating children's hands-on skills and creativity should be emphasized, so as to strengthen parents' purchasing intentions.

5.2. Design Rationale and Objectives

SnapPen's design aims to explore practical ways to apply sustainable design principles in the field of children's products through the hybrid design of stationery and toys. The overall design goal can be divided into four interrelated dimensions: lifespan, material, structure, and interaction.. In terms of lifespan extension, the design aims to transcend the linear "use and disposal" mode of traditional stationery, in which the exhaustion of functions will trigger immediate disposal. Through functional hybridization, once the writing function ends, the product will be transformed into a construction toy, thus prolonging its service life and delaying replacement. In terms of materials, products should use material systems with sustainable characteristics and recycling potential, while ensuring the safety of children, so as to reduce the environmental burden throughout the life cycle. At the structural level, modular design should be adopted to standardize basic units and realize their reorganization, allowing individual components to participate in multiple reconfiguration processes, and supporting diversified functional and formal expansion. At the interaction level, the product should be consistent with the characteristics and movement ability of children's hand scales, and maintain low learning costs and high operational intuition in the process of grasping, usage and reconfiguration, so as to ensure consistent usability in different functional states. These four dimensions reinforce one another and jointly form

a systematic goal framework designed by SnapPen.

5.3. Design Strategy and Product Presentation

SnapPen uses a combination of functions to combine watercolor pen writing and block assembly, breaking the traditional boundaries between stationery and toys. The modular design uses the pen body as a basic unit with a standardized slot connection to achieve free reconfiguration - each component can be used as a structural element after writing. In terms of behavior, it has changed from the use of a single tool to a participatory construction, thus enhancing the degree of participation. The implementation involves structure (stable slots, transparent cap with bearing capacity), materials and ergonomics or consistent user experience across writing and assembly.

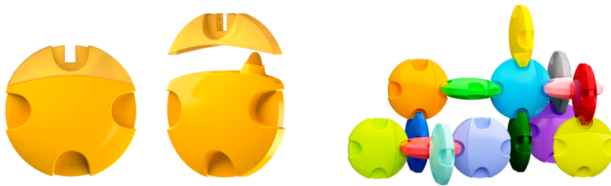


Figure 3. Single-unit display of SnapPen and Assembled configuration of SnapPen.

Image source: Author's own work

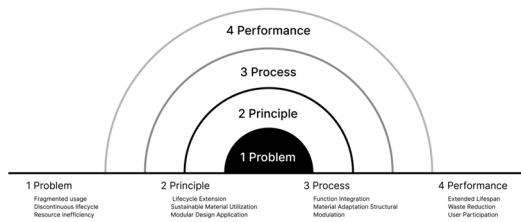


Figure 4. Design concept of SnapPen. Image source: Author's own work

6. Conclusion

This study explores the hybrid design as a sustainable strategy for children's stationery and toys, using SnapPen, a watercolor pen that can be converted into building blocks, as a practical case. Based on the theory of circular economy and lifespan extension strategies, the study shows that functional hybridization, modular structure, and sustainable material selection can effectively bridge the traditional divide between practical stationery and entertainment toys. Research results show that hybrid design extends product life through functional conversion and emotional participation, reduces

children's discard intentions, and cultivates environmental awareness. User research confirms confirms strong parental acceptance of modular approaches, particularly for younger children who exhibit higher replacement rates. SnapPen provides a replicable reference model for the design of sustainable children's products, which helps responsible consumption and production practices.

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