Children's Toy Design: Taking the Design of Ecological Observation Toy Box as an Example

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Abstract. Currently, insufficient contact between children and the natural environment has become a prominent public health and educational issue. This trend is mainly driven by two factors: the expansion of built environments and the increasing amount of time spent on screens, which puts children's physical and mental development at multiple risks. Taking the ecological observation toy box from educational toys as an example, this paper analyzes the key points in children's toy design. Based on relevant research projects and from the perspectives of children's cognitive psychology and behavioral science, children in the age range of 6-12 years old are identified as the target user group for this study. Additionally, the different needs of children and parents regarding toys are analyzed, a balance is sought between these needs, and the design principles for children's toys are summarized. Building on earlier research, the study's findings were applied to real-world design projects, leading to the creation of an ecological observation toy box tailored to children aged 6-12. By combining theory with practice, the whole research process became more complete.

Keywords: Toy design, school-age children, ecological observation.

1. Introduction

Children's direct contact with the natural environment has been decreasing amid the dual context of accelerating urbanization and widespread use of electronic screen devices. This trend has emerged as a significant public health and educational concern affecting children's physical and mental well-being, which is the focus of this study. The phenomenon not only restricts children's intuitive understanding of the natural world but may also weaken their perceptual skills, hands-on abilities, and ecological awareness. Therefore, research into toy design that fosters children's connection with nature holds important practical and educational value.

This study centers on the design of ecological observation toy box, targeting children aged 6-12. By integrating theories from child cognitive psychology and behavioral science, it conducts an in-depth analysis of the psychological characteristics, behavioral patterns, and actual needs of children in this age group. Based on these findings, toy design principles emphasizing fun, educational value, and safety are proposed and validated through specific design practices. For the research methodology, relevant academic literature, design cases, and educational policies from both domestic and international sources were systematically reviewed and analyzed. This approach enables a comprehensive understanding of current research status and design trends, providing theoretical support for subsequent user analysis and design practice. Additionally, in-depth exploration of the dual needs of children and parents was conducted through case analysis and user surveys, ensuring the scientific rigor and practical applicability of the design proposals.

The ultimate research objective of this study is to establish an ecological observation toy box design system suitable for children aged 6-12 years, encompassing structural design, functional modules, and usage scenarios. Furthermore, universal design principles for children's toys will be derived to offer references for design practice in related fields. To achieve this goal, this article begins with an analysis of users' cognitive characteristics, followed by a step-by-step exploration of needs assessment, design implementation, and principle summarization, aiming to build an organic link between theory and practice.

2. Concept

Nowadays, as urbanization speeds up and electronic screens are widely used, children's direct contact with the natural environment is on the decline, posing new challenges to their physical and mental health development. The "ecological observation toy box" mentioned in this study is precisely the design solution proposed for this contemporary issue. Children's toys come in a rich variety. Classified by function, they can be divided into educational, sports, role - playing, etc. The ecological observation toy box is a miniaturized, semi - controllable dynamic natural system simulation device, and it belongs to the educational toys with natural education functions. Its core is to break spatial limitations, bring real natural ecology into children's daily life, and create a space where they can observe, operate and interact.

This design targets children aged 6 to 12. At this stage, children are in the "concrete operational phase" of cognitive development, brimming with strong curiosity and a thirst for exploration, and mainly rely on direct perception and hands-on activities to make sense of the world. The ecological observation toy box creates a safe and engaging environment for exploration, guiding children to shift from passive screen watchers to active nature discoverers. It not only effectively develops their scientific observation, logical thinking, and hands-on skills but also subtly fosters values and a sense of responsibility centered on reverence for life and care for nature.

3. User Analysis

3.1. Analysis of Children’s Cognitive Characteristics

The period from 6 to 12 years old is a crucial stage in children's cognitive development. Their psychological characteristics, behavioral patterns, color perception, motor skills and other aspects all exhibit distinct stage features. Accurately grasping these features is of great significance for toy design.

According to Piaget's theory of cognitive development, children aged 6 to 12 are in the concrete operational stage. They gradually grasp logical concepts like conservation, classification, and serialization, yet their thinking still relies on concrete objects and experiences. In this stage, children's attention span is significantly prolonged, and they can sustain intentional attention for 20 - 40 minutes. Moreover, memory strategies shift from mechanical memory to meaningful memory. Moral concepts evolve from heteronomy to autonomy, and they start to understand the flexibility of rules. Meanwhile, self - awareness is strengthened, and they have a yearning for a sense of accomplishment and recognition [1].

School-age children exhibit strong exploratory behavior and social needs. They enjoy taking apart, assembling, and reconstructing objects to understand the world through hands-on manipulation. Their play transitions from parallel play to cooperative play, allowing them to comprehend and follow rules while engaging in organized group activities. Collecting becomes particularly prominent during this stage, as they derive satisfaction from gathering, categorizing, and displaying items.

Children aged 6 - 8 prefer primary colors (red, yellow, blue) with high saturation and strong contrast, as these colors can directly stimulate their interest in playing games. Children aged 9 - 12 gradually develop more sophisticated color aesthetics, begin to like the combination of secondary and tertiary colors, and can grasp the connections between colors, emotions, and functions. Studies have shown that warm colors like red and orange can boost excitement and motivation, while cool colors such as blue and green help with concentration. Therefore, toys for young children should use bright and vibrant color combinations, and toys for older children can employ more coordinated and understated color schemes [2].

During the school-age period, children's large muscle group Motor Abilities develop rapidly. They enjoy large-movement games such as running, jumping, and throwing, and their motor coordination and balance improve significantly. The control ability of small muscle groups gradually becomes refined. At 7-8 years old, they can complete tasks such as buttoning and tying shoelaces; at 9-10 years

old, they can use simple tools more skillfully; and at 11-12 years old, they can complete more complex operations.

3.2. User Requirements Analysis

The core user group for this study consists of school-age children aged 6 to 12 and their parents. Consequently, toy design must satisfy the needs of both parties. While children prioritize fun, engagement, and a sense of accomplishment, parents value educational benefits and safety. This chapter will analyze the distinct needs of children and parents separately and examine how to balance these two perspectives.

3.2.1. Analysis of children's user requirements

Children are users of toys, and their preferences directly determine the vitality of toys. For school - age children aged 6 - 12, their needs have moved from simple sensory stimulation in early childhood to more complex psychological pursuits.

Interest is the primary factor to attract children and the fundamental starting point of toy design. For school - age children, it stems from exploration, creation and challenge. For example, toys with hidden mechanisms and needing decryption can satisfy their desire for knowledge; scenario simulation toys have a sense of role immersion and will be extremely appealing; toys with certain rules like strategic board games can let children gain pleasure in challenges [3].

Children have a desire to take the lead in games instead of being passive recipients, and engagement is the key to continuous appeal. Toy design should encourage children to get hands - on, starting with offering manipulable components or choices. For example, robot assembly toys enable children to assemble freely and control their movements, making them feel that they are the masters of the game and immerse themselves in it.

A sense of accomplishment is the psychological feedback obtained by children from toys, which can help them build self-confidence. Toys should bring satisfaction and a sense of self-identity to children through providing timely positive feedback. For example, successfully assembling a 1000 - piece puzzle, constructing a grand LEGO castle, and getting the hang of the tricky skills of a yo - yo, so that children's efforts can be noticed and acknowledged.

3.2.2. Analysis of parent user's requirements

Parents are the ones who decide on toy purchases, and their needs are more centered on the long - term development and practical aspects of children.

Educational value is an important criterion for parents to evaluate the worth of toys. Parents hope that toys can integrate education with entertainment, subtly nurturing children's abilities during play, like knowledge acquisition, skill development, and social interaction. Popular science toys with scientific knowledge can exercise children's logical thinking. Multiplayer board games can effectively foster children's team collaboration and communication skills. Learning through playing and playing while learning.

Safety is the fundamental requirement for parents when making a choice. This includes three levels: 1. Physical safety: The material of the toy is non-toxic and harmless, the structural design is round without sharp corners, small parts are firmly attached and not easy to come off to prevent accidental swallowing, and it complies with national safety standards like the 3C certification. 2. Psychological safety: Toys should convey positive and healthy values, avoiding elements like violence and horror. The colors and sounds should also be comfortable and enjoyable, steering clear of excessive stimulation. 3. Digital Security: For internet - enabled smart toys, data privacy protection and content filtering mechanisms are of utmost importance. Parents need to make sure that their children's information isn't leaked and the online content they come across is healthy and free from harm [3].

3.2.3. Exploring the balance bridge between fun and educational expectations

The needs of children and parents are not in opposition. A balance should be found by toy design between children's exploratory fun and parents' educational expectations. The educational purpose

should be concealed under the game mechanism, and a bridge connecting the two should be constructed. Designers can use rule design and interactive design to make knowledge, skills, and values the tools that children actively employ to reach game objectives.

4. Design Practice of Ecological Observation Toys - Ecological Observation Toy Box Design

4.1. Design Drawings

A detailed analysis of the drawing design was conducted for the ecological observation toy box for children aged 6 - 12. Finally, the following design drawing was identified as the initial draft of the design model (Figure 1).

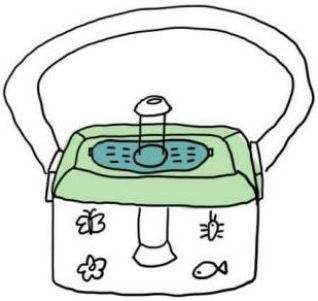

Figure 1. Design Sketch of ecological observation toy box for Children Aged 6 - 12

The overall effect diagram created with computer software is shown in Figure 2.

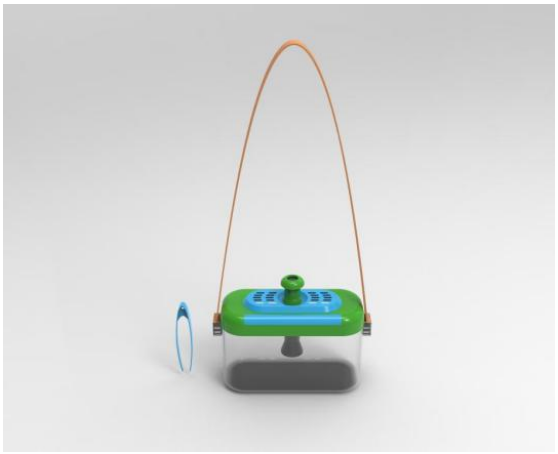

Figure 2. Design Rendering of ecological observation toy box for Children Aged 6 – 12

The effect diagram of children carrying ecological observation toy box is shown in Figure 3.

Figure 3. Carrying Effect Diagram of Children's ecological observation toy box

4.2. Structural Design Description

The box structure is made of high - transparency polycarbonate material, which offers excellent optical properties and impact resistance. The size of the box (Figure 4) is 15×7×9.5 cm, which not only ensures sufficient observation space but also is convenient for children to hold and operate. The box adopts a cylindrical corner design to avoid safety hazards caused by sharp angles and at the same time enhance the structural stability. Colors with high saturation such as blue, green, and orange, along with bright and understated color combinations, not only boost excitement and the desire for activity but also help children focus their attention.

Figure 4. Detail view of ecological observation toy box casing

An observation door of 13×5 cm is opened at the top of the box (Figure 5), and a snap - fit switch structure is adopted. The opening force is specially adjusted (≤2N) to ensure that children can operate independently and avoid accidental opening. The door frame is equipped with a silicone seal strip to ensure airtightness when closed. Ventilation holes are provided at the top, allowing air to circulate while preventing organisms from escaping.

Figure 5. Detailed view of the observation door of ecological observation toy box

A telescopic magnifying glass (Figure 6) is embedded in the observation door on the box top. There are protrusions on the side that match the groove of the observation door, enabling children to freely extend and retract up and down. The connection part is a spherical structure, ensuring that the telescopic lens can rotate 360 degrees, and can observe any corner in the housing. A magnifying glass is installed on the top, with a magnification of 3 times, which is convenient for detailed observation.

Figure 6. Detailed view of the telescopic magnifying glass of ecological observation toy box

Safety tweezers designed to fit the hand shape is specially equipped for children (Figure 7). It is 8.5 cm long, and the tip of the tweezers is treated with round blunting to avoid injury from sharp parts. The surface of the tweezers is treated with anti-slip textures to enhance the gripping stability. A small groove is opened on the side of the top of the housing, which is beneficial for the storage of the tweezers.

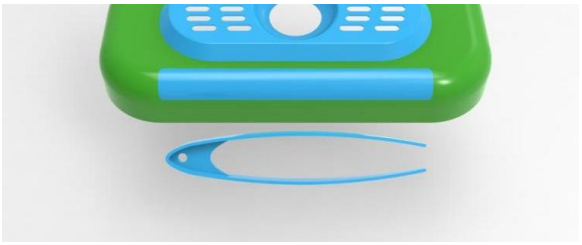

Figure 7. Detail view of the safety tweezers of ecological observation toy box

Detachable shoulder strap buckle points are provided on both sides of the top of the box, along with an adjustable nylon shoulder strap that is 2 cm wide (Figure 8). The shoulder strap length can be freely adjusted between 50 - 80 cm, suitable for children of different heights to carry over the shoulder or by hand. A reinforced rotating buckle at the connection of the shoulder strap and the case ensures load-bearing safety and prevents the strap from winding, allowing children to free their hands when exploring outdoors. Moreover, the inner side of the shoulder strap features breathable sponge padding, reducing shoulder pressure and enhancing the comfort of long - term carrying.

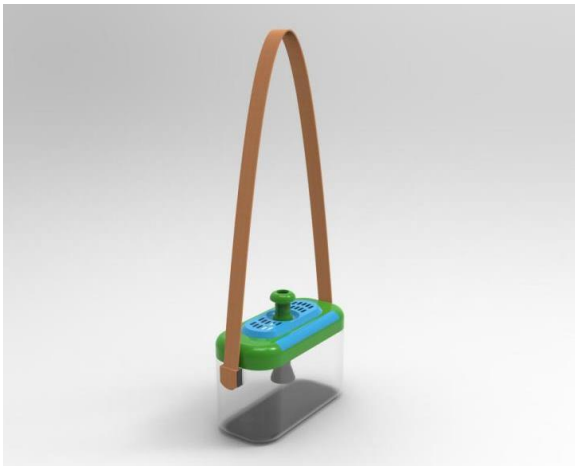

Figure 8. Detailed view of the shoulder strap of ecological observation toy box

4.3. Diversified Scenario Applications

The ecological observation toy box supports various observation themes, including insect observation, plant research, geological collection, and water ecosystem observation. It caters to children's different exploration interests, greatly enhancing the toy's usability and making it a versatile tool for children to explore nature. The effect diagrams of four different application scenarios are shown in Figure 9.

Figure 9. Four application scenario effect diagrams of ecological observation toy box

5. Design Principles for Children's Toy Products

Based on in - depth analysis of the core needs of children aged 6 to 12 and their parents, toys should adhere to scientific and systematic design principles. This chapter will center on the four core principles of functionality, interactivity, safety, and educationality for discussion, thus offering practical theoretical guidance for children's toy design.

Functions determine the basic use and value of toys, and toys should serve as windows for children to observe the world and grasp rules. Designers can integrate phenomena from natural sciences into toys. For example, bionic toys can imitate the mechanical structures of birds flying and spiders weaving webs to guide children to observe and understand the underlying principles, transforming static knowledge into a dynamic and visible exploration process. This not only aligns with children's curiosity but also meets parents' expectations for knowledge enlightenment [4].

Design should fully engage multiple sensory channels like vision, hearing, and touch to create an immersive experience. At the same time, every operation should offer clear and timely feedback, be it the light and sound from the button, the "click" when assembling parts, or the progress bar indication. This feedback mechanism can help children strengthen their sense of involvement and accomplishment, and also motivate them to explore further [5].

Materials should use non-toxic materials like food-grade silicone and ABS eco-friendly plastic, and strictly comply with safety standards. For structural design, round corners are needed to avoid scratching, and small components should be eliminated to prevent the risk of accidental swallowing. In terms of craftsmanship, it should be firmly assembled and able to withstand repeated use, thus fundamentally removing potential safety hazards [5].

Adopting task-oriented design, like specimen collection and challenging levels, children can actively learn while completing engaging tasks. This design turns knowledge acquisition into an exploration process, not only retaining the fun of the game but also achieving educational goals such as cognitive development and creativity cultivation, thus realizing the integration of education and entertainment.

6. Conclusion

This study completed the design practice of ecological observation toy box and refined four core principles for children's toy design: functionality, interactivity, safety, and educational value by systematically analyzing the cognitive development traits and user needs of children aged 6-12 and integrating the concept of ecological education. Specifically, the toy box designed in this paper is made of high-transparency polycarbonate material and equipped with modules including a retractable magnifying glass, safety tweezers, and an adjustable shoulder strap. Various scenarios such as insect observation, plant research, geological collection, and aquatic ecological observation are supported. It not only meets children's desire for exploration and hands-on needs but also matches parents' expectations for safety and educational value. This design successfully builds a balanced bridge between children's instinct to "play" and parents' expectation to "teach" by integrating natural phenomena into the toy mechanism.

This study offers valuable insights for future children's toy design, with key impacts in the following areas: 1. Theoretically, it reinforces the application of user-centered design principles in children's product development; 2. Practically, it provides actionable solutions for creating educational toys amid the "nature deficit disorder" context, helping drive the toy industry toward greater educational value and environmental awareness.

Future research should focus on these directions for deeper exploration: 1. Expand the target age ranges, including tailored designs for 3-6 year-old children or teenagers over 12; 2. Incorporate smart technology features, such as using AR (Augmented Reality) to improve observation experiences or developing apps for recording observation data; 3. Strengthen interdisciplinary collaboration by bringing in perspectives from education, ecology, and materials science to further enhance the scientific basis and sustainability of toys. With ongoing improvements and creative updates,

ecological observation toys are set to become a key way to link kids with nature. They can bring more attention to nature and a spirit of discovery to the overall development of the next generation.

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