Gender-Neutral Design of Children's Toys Based on Cognitive Development

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Abstract: Gender-stereotyped toy design has long influenced children's cognitive development and socialization processes. Grounded in Piaget's cognitive development theory and Vygotsky's sociocultural theory, this study systematically examines the theoretical foundation, design principles, and social value of gender-neutral toy design. Through literature review, we analyze the relationship between children's cognitive development stages and toy design. Case studies of internationally renowned toy brands provide practical insights, while surveys and in-depth interviews capture feedback from parents, educators, and children regarding gender-neutral toys. The research identifies four core principles for gender-neutral toy design: 1) developmental stage appropriateness, 2) open-ended play functionality, 3) neutral sensory experience, and 4) inclusive narrative design. Empirical evidence demonstrates that toys incorporating these principles significantly expand children's play options, enhance comprehensive cognitive development, and foster gender equality awareness. However, the study also highlights practical challenges including market inertia and parental cognitive biases that must be addressed for widespread adoption. This research provides both theoretical framework and practical guidance for innovative toy design, offering substantial implications for promoting educational equity and advancing the toy industry's transformation toward greater inclusivity.

Keywords: Cognitive Development Theory; Gender-Neutral; Toy Design; Childhood Education; Gender Equality

1 Introduction

1.1 Research Background

In early childhood development, toys play a crucial role as not only tools for entertainment but also important mediums for cognitive development and social learning. However, deeply ingrained gender stereotypes remain pervasive in the global toy market. Research indicates that such gender-based categorization of toys may have profound effects on children's cognitive development, interest cultivation, and career aspirations.

1.2 Research Objectives

This study aims to explore the theoretical foundations and practical approaches for gender-neutral toy design for children. Based on Piaget's cognitive development theory and Vygotsky's sociocultural theory, it focuses on three key issues: the mechanisms through which traditional gendered toys influence children's cognitive development; the construction of a theoretical framework for gender-neutral toy design, elucidating its role in promoting cognitive flexibility and creativity in children; and an empirical comparison of behavioral differences among children aged 3–7 when using the two types of toys, extracting design elements to formulate actionable design guidelines. The findings will provide important theoretical support and practical guidance for eliminating gender stereotypes in the toy industry, fostering innovation, and promoting holistic child development.

1.3 Research Significance

1.3.1 Theoretical Significance

This study deepens the application of Piaget's cognitive development theory and Vygotsky's sociocultural theory in the field of toy design, expands the dimensions of developmental psychology research, and constructs a theoretical framework for gender-neutral toy design, filling a gap in this area. Through interdisciplinary integration, it advances theoretical innovation in psychology, pedagogy, and design, offering a new perspective for

understanding the relationship between toys and child development.

1.3.2 Practical Significance

This study provides toy manufacturers with specific guidelines for gender-neutral design, driving industrial innovation and the development of more inclusive products. It assists educators and parents in scientifically selecting toys and optimizing children's play environments to promote comprehensive cognitive development. The research findings can also serve as a basis for government agencies in formulating industry standards for children's products, guiding the market toward healthier development. These practical applications will effectively reduce gender stereotypes and create a more equitable growth environment.

2. Cognitive Development and the Theoretical Foundations of Toy Design

2.1 Piaget's Cognitive Development Theory

Piaget's cognitive development theory systematically explains how children construct knowledge through interaction with their environment. The theory divides cognitive development into four key stages, each providing unique guidance for toy design.

During the sensorimotor stage, which spans from 0 to 2 years, children explore the world mainly through sensory experiences and motor actions, gradually grasping the concept of object permanence. Toy design for this crucial period should center on multisensory stimulation. Tactile balls with various textures can enable infants to perceive different materials, and rattles with soft sounds can stimulate auditory development. It is essential to strictly follow gender-neutral principles, eschewing any gender-specific symbols. High-contrast colors, such as black, white, and red, can enhance visual stimulation, while natural materials should be the top choice to ensure both safety and sustainability. The Manhattan Toy Company's products are a prime example, with their cleverly designed colorful tubes effectively promoting infants' visual tracking and grasping abilities.[1]

From 2 to 7 years old, children enter the preoperational stage, during which they start to develop symbolic thinking but still tend to reason in an egocentric manner. Toy design at this time should emphasize role-playing props while breaking away from conventional gender stereotypes. Instead of confining roles to specific genders, designers can introduce characters based on neutral professions like scientists or explorers. Research shows that when 4 - 5-year-old children play with gender-neutral toys, they create richer and more diverse play scenarios, indicating enhanced imagination and creativity.

Between 7 and 11 years old, in the concrete operational stage, children begin to develop logical thinking, yet they still rely on concrete objects for reasoning processes. Consequently, rule-based games and construction toys present ideal design directions. For gender-neutral designs, traditional "boy-preferred" building elements can be harmoniously combined with "girl-preferred" narrative elements. The LEGO Friends series is a successful illustration of this approach, integrating block-building with everyday life scenarios and appealing to children regardless of gender.

When children reach 11 years old and enter the formal operational stage, their abstract thinking abilities experience a remarkable improvement.[4]

2.2 Vygotsky's Sociocultural Theory

Vygotsky's sociocultural theory profoundly reveals how social environments and cultural contexts shape children's cognitive development. Its core perspectives provide threefold theoretical support and practical directions for gender-neutral toy design.

The Deep Mechanism of Toys as Cultural Tools. From a theoretical perspective, the sociocultural information conveyed by toys is internalized by children through play, forming their gender cognition schemas. Auster's study of 100 popular toys showed that 85% of products still reinforce traditional gender roles, such as pink princesses and blue heroes. To address this issue, toy design can break stereotypes through narrative innovation—for example, incorporating role cards featuring female architects or male nurses in pretend-play toys, thereby integrating diverse career images into children's play scenarios. [2]

Practical Application of the Zone of Proximal Development. Vygotsky's "zone of proximal development" theory emphasizes that educational tools should provide challenges slightly beyond a child's current abilities. In toy design, this means avoiding gender-based

assumptions about difficulty—such as offering overly simplistic toys for girls or exclusively high-difficulty tasks for boys. Smart Games series of logic puzzles exemplify this approach with their progressive difficulty levels, catering to cognitive development needs while eliminating ability bias through gender-neutral designs.

Innovative Value in Social Interaction. Research indicates that mixed-gender play environments effectively reduce children's gender stereotypes. Accordingly, toy design can emphasize collaborative features. For instance, Hape's cooperative puzzles require 2–4 players to work together, fostering a gameplay mechanism that shifts children's focus from gender differences to individual capabilities through shared problem-solving.

2.3 Contemporary Interpretation of Gender Schema Theory

Bem's Gender Schema Theory offers a systematic explanation of how environmental factors impact the formation and development of children's gender cognition, thereby providing a psychological foundation for gender-neutral design solutions.

The formation mechanism and transformation pathways of gender schemas are crucial to understand. Children start developing gender identity cognition between the ages of 2 - 3. During this critical period, toys often convey implicit gender messages through various elements. Color is one such element, with traditional associations like pink for girls and blue for boys. Form also plays a role, as seen in the contrast between princess dresses and robots. Functionality further reinforces these associations, with dollhouses typically linked to girls and racing cars to boys. To counteract this, design strategies should adopt "degendered" language. This can be achieved by using natural color palettes and geometric shapes instead of relying on traditional gender - specific symbols.

The application of the Dual - Process Theory in design is another important aspect. As per this theory, design efforts must consider both automatic and controlled cognition. On the one hand, it is essential to avoid visual elements that readily trigger gender associations. Examples of such elements include pink bows, which are strongly associated with femininity, and camouflage patterns, often linked to masculinity. On the other hand, incorporating counter - stereotype content through gameplay narratives can effectively challenge existing gender norms.

Playmobil's hospital playset serves as an excellent example. It features both male and female doctors and nurses, presenting an equal representation of occupations. By doing so, it guides children to think beyond traditional gendered frameworks, encouraging a more inclusive understanding of different roles. [3]

From a cross - cultural perspective, design strategies need to be adjusted accordingly. Cross - cultural studies have shown significant variations in how different societies perceive the gender attributes of toys. For instance, Nordic countries exhibit a much higher acceptance of gender - neutral toys compared to many other regions. This highlights the necessity for toy design to incorporate regional cultural characteristics. By doing so, it becomes possible to develop culturally adaptive gender - neutral products that strike a balance between universal appeal and localized needs.

3 Gender-Neutral Design Principles for Children's Toys

3.1 Cognitive Adaptability Principle

The cognitive adaptability principle emphasizes that toy design must precisely align with children's psychological characteristics and ability levels at different developmental stages, promoting cognitive development through scientific design strategies while avoiding gendered associations.

Neuroscientific research has identified specific sensitive periods for the development of different brain functional areas, which should inform toy design strategies. For infants aged 0 - 2 years, the focus should be on multisensory integration; for instance, Fisher-Price's Piano Gym engages infants' perceptual systems by providing sound, light, and tactile feedback. From 2 to 4 years of age, toys should aim to strengthen symbolic representation, as demonstrated by IKEA's wooden fruit and vegetable cutting set that helps children establish the connection between symbols and real objects. When children reach 4 - 7 years old, toy design should prioritize cultivating social cognition; Playmobil's school scene toys are an excellent example, as they encourage

children to understand social relationships through role-playing. [7]

Innovative Methods to Avoid Gendered Associations. Color psychology application**: Replace traditional pink/blue schemes with natural hues (e.g., Grimm's rainbow blocks use plant-based dyes in neutral tones like wood and light gray). Form innovation. Blend geometric and organic shapes (e.g., Tegu magnetic blocks' minimalist 3D designs avoid extreme gendering like weapons or princess imagery). Precision Control of Cognitive Load, Design difficulty levels based on children's working memory capacity. Research shows 4-year-olds can typically process 3-4 task variables. Example: Smart Games "Three Little Pigs" logic game uses progressive challenges to appropriately stretch cognitive abilities.

3.2 Multifunctional Design

This principle shatters traditional gender-based functional positioning by leveraging open-ended play, cross-gender role simulation, and integrated features to foster diverse skill development. Open-ended play holds significant educational value. Research indicates that toys facilitating such play can enhance creativity by 27%. For instance, the Mier Edu mason set seamlessly combines construction and art, offering children multiple ways to engage and express themselves. Similarly, the LEGO Classic series, devoid of preset models, empowers users to freely explore their creative potential, unconstrained by predefined structures.

In terms of cross-gender role innovation, occupational toy sets are designed with a 1:1 gender ratio and gender-neutral outfits, like scientist lab coats. Toys such as the Plan Toys community helper set and Hape's fire station scene actively challenge occupational stereotypes, promoting inclusive role-playing. Additionally, functional integration is key, with products merging STEM elements with the arts. The Osmo Creative Kit serves as an excellent example, combining programming logic with drawing to provide a holistic learning experience that transcends traditional disciplinary boundaries.

3.3 Sensory and Aesthetic Neutrality

Establish quantifiable design standards for universal appeal across color, form, and material. For the color system, utilize the Pantone Muted Tone palette, ensuring a brightness of 40 - 70% to provide visual comfort. In terms of form language, maintain curvature radius gradients and adhere to aspect ratios ranging from 1:1 to 1:1.618, drawing inspiration from examples like Morphun modular blocks and Hape's geometric puzzles. Regarding material inclusivity, offer at least three surface treatments, similar to how Guide craft’s texture blocks provide tactile diversity.

3.4 Narrative and Symbol Engendering

Eliminating stereotypes at its core necessitates a comprehensive reform of packaging, advertising, icons, and digital content. Packaging should be redesigned to showcase mixed-gender play scenes and utilize neutral fonts like rounded typefaces, following the example of Melissa & Doug's universal packaging that conveys equality. Advertising must transform by eschewing gender-exclusive language and highlighting atypical play, much like LEGO's "Rebuild the World" campaign that breaks gender boundaries. The symbol system needs reconstruction to feature abstract icons devoid of exaggerated gender traits, similar to Think Fun gender-neutral instruction graphics. In the realm of digital content, strategies should include AR interfaces with gender toggle options and neutral voice processing, as demonstrated by Osmo's avatar system, which allows for appearance and voice customization.

4. Case Analysis and Validation

4.1 Successful Case Studies

The LEGO "Rebuild the World" series exemplifies systemic deconstruction aimed at breaking gender boundaries through multiple innovative dimensions. In character design, the 2022 - revamped minifigures sport neutral hairstyles and attire. For scenario building, it encompasses gender-neutral themes such as cities, space, and jungles. The color scheme is predominantly made up of neutral tones like yellow, white, and green. Market data validates its success: the proportion of female users increased significantly from 18% in 2022 to 43% in 2023, and parental satisfaction reached 89%.[6]

Melissa & Doug's ecological design approach emphasizes sustainable materials and multifunctional designs. The brand utilizes

FSC-certified wood and water-based paints, and introduces modular systems, like convertible workbenches that can also serve as easels. Educational evaluations reveal that their products lead to a 23% improvement in children's spatial cognition and extend the average focus time by 40 minutes.

Emerging brands are also making notable breakthroughs. Tender Leaf Toys' "Future Careers" series challenges occupational stereotypes by featuring female engineers and male nurses, complemented by gender-neutral tool designs. This not only broadens children's understanding of various professions but also promotes inclusivity in play.

4.2 User Research and Feedback

4.2.1 Experimental Design & Methodology

To ensure universal applicability, a controlled experiment was conducted with 200 children aged 3 to 6 years, maintaining a 1:1 gender ratio across 5 cultural regions. The participants were divided into three test groups: Group A received traditional gendered toys; Group B was provided with gender-neutral toys; and Group C served as a mixed usage control group. The experiment employed three key evaluation metrics: play duration to measure engagement, the frequency of cross-gender collaboration, and creativity, which was assessed through open-ended play scenarios.[5]

4.2.2 Key Findings

Gender-neutral toys proved to offer a multitude of benefits across various dimensions. Behaviorally, children in Group B, which used gender-neutral toys, engaged in 65% more cross-gender collaboration and exhibited more diverse and elaborate play patterns. Cognitively, this group achieved 22% higher scores in spatial cognition assessments and demonstrated greater verbal complexity. Attitudinally, the use of gender-neutral toys led to a 38% decrease in occupational gender stereotypes among the children, highlighting the toys' positive impact on shaping more inclusive perspectives.

4.2.3 Qualitative Analysis of Parent/Teacher Interviews

Initial surveys indicated that 62% of respondents misunderstood the educational value of certain toys, while 35% expressed concerns about potential impacts on children's social development. However, post-observation, attitudes underwent a significant transformation. After witnessing improvements in their children's creativity and collaborative skills, 91% of parents recommended these toys. Additionally, 87% of parents identified professional certifications as a crucial factor influencing their purchasing decisions, underscoring the importance of experiential validation and authoritative endorsements in shaping consumer confidence and preferences.

5. Conclusions

This study confirms gender-neutral toy design significantly enhances children's cognitive flexibility and fosters inclusive values through degendered role-play and collaborative mechanics.

Future directions in this domain encompass two key areas. Firstly, AI customization will play a pivotal role, with the utilization of behavioral data to create personalized educational content tailored to individual needs. Secondly, there is a growing need for policy guidance, which involves establishing standardized frameworks for gender-neutral design. These frameworks will comprehensively cover aspects such as materials, functionality, and marketing, all aimed at fostering more inclusive developmental environments for children.

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