Research on Interactive Design of Children's Waste Sorting Education under the Concept of Sustainable Design

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Abstract. To address the challenges of abstract cognitive processes, low participation, and difficulty in solidifying behaviors in current waste sorting education for children, this study conducts an interactive design research project on waste sorting education for preschool children, based on sustainable design principles. Initial needs information was obtained through questionnaires, user interviews, and behavioral observation. The Key-J method was used to summarize and integrate this information, extracting core needs. Based on this, a sustainable-oriented interactive design framework for children's waste sorting education was constructed, incorporating contextual guidance, sensory interaction, immediate incentives, and behavioral reinforcement mechanisms. The research shows that this design effectively enhances children's learning interest and sustained participation, promoting the transformation of waste sorting knowledge into stable environmentally friendly behaviors, and providing practical reference for the application of sustainable design principles in children's education and interactive art.

Keywords: Sustainable Design, Children's Education, Waste Sorting, Interaction Design, KJ Method.

1 Introduction

Against the backdrop of the ongoing advancement of the "dual carbon" strategy and ecological civilization construction, garbage sorting has become an important measure to promote green lifestyles and sustainable social development[1]. Foreign studies focus on gamified interaction, multi-sensory experience and environmental awareness cultivation[2-3]; domestic studies focus on waste sorting teaching aids, interactive devices and APP development, but mostly on knowledge transmission and short-term fun, lacking systematic design for behavior formation and long-term solidification from a sustainable perspective[4]. The childhood stage is a critical period for the formation of environmental awareness and behavioral habits, and traditional education methods are difficult to adapt to the cognitive characteristics of preschool children. Existing interactive designs generally have problems such as insufficient embedding

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of sustainable concepts, weak behavior formation mechanisms and insufficient integration of educational scenarios. To this end, this study takes sustainable design as a guide, uses user surveys and KJ method to extract needs, constructs interactive design strategies and carries out practice, strengthens children's environmental awareness and behavior formation in a contextualized and visualized way, improves the effect of waste sorting education, and provides a reference for the application of sustainable concepts in children's education and interactive design.

2 KJ Method Concept Analysis

The KJ method, also known as the affinity diagram method, was created by Japanese scholar Jiro Kawakita. It is a qualitative research method that transforms scattered and unstructured information into systematic conclusions through induction, classification, and integration[5]. This method completes natural grouping based on the inherent correlation between information, does not rely on a pre-set framework, and can objectively extract user needs and core issues. It is widely used in user research and interaction design for needs analysis, problem analysis, and design direction derivation.

3 User Survey and Needs Analysis on Children's Waste Sorting Education

3.1 Questionnaire and Survey Participants

This study focuses on preschool children. Children are direct participants in waste sorting education, and their cognitive characteristics and behavioral performance determine the basic direction of the interaction design. Considering that preschool children's cognitive and expressive abilities are not yet fully developed and they may find it difficult to complete standardized questionnaires independently, parents and teachers were included as the survey subjects. A questionnaire entitled "Children's Waste Sorting Education APP Usage" was designed and distributed (see Table 1).

Table 1. Questionnaire survey structure.

Questionnaire Structure	Survey Content
Basic Information	Child's age, child's gender, and class
Current State of Education	Knowledge of waste sorting, current learning methods, and existing problems
Willingness to Use	Willingness to use a waste sorting education app and level of acceptance of digital learning
Functional Requirements	Knowledge learning, interactive games, instant feedback, and reward mechanisms
User Suggestions	Expectations for the app and other suggestions

3.2 Questionnaire Survey Analysis

This study distributed online questionnaires to parents and teachers of children through Wenjuanxing, collecting a total of 142 questionnaires. After removing 17 invalid questionnaires, 125 valid questionnaires were obtained, with an effective rate of 88.0%.

The results of the reliability and validity test showed that Cronbach's α coefficient was 0.894, KMO value was 0.872, and Bartlett's test of sphericity was significant ($p<0.001$), indicating that the questionnaire had good reliability and validity. The survey results showed that 89.6% of the respondents were willing to let their children use the garbage classification education APP to assist in learning, 85.4% of the respondents believed that interactive games could enhance learning interest, and 81.7% of the respondents believed that immediate feedback and reward mechanisms would help enhance the willingness to continue participating, indicating that users have a high degree of recognition for fun and interactive garbage classification education methods.

3.3 User Interview Analysis

To gain a deeper understanding of children's learning needs regarding waste sorting, this study employed semi-structured interviews[6], interviewing 10 preschool children, 6 parents, and 3 kindergarten teachers. The results showed that children preferred learning through animation and games; parents hoped to leverage digital tools to enhance learning interest and view feedback; and teachers felt that existing teaching resources lacked interactivity. Overall, the main needs focused on making knowledge presentation more intuitive, the learning process more engaging, feedback mechanisms more immediate, and behavior development more sustainable.

3.4 Behavioral Observation and Analysis

To understand children's behavior in learning about garbage sorting, this paper selected 5 preschool children for behavioral observation. The results showed that children are more easily attracted by brightly colored and visually intuitive elements, and tend to complete tasks through simple operations such as clicking and dragging. When the system provides animation, sound effects and reward feedback, children show higher participation enthusiasm and willingness to continue learning. Compared with text explanation, contextualized and gamified interactive forms are more helpful for children to understand garbage sorting knowledge and maintain their interest in learning.

3.5 User Needs Collection and Summarization Based on the KJ Method

After completing the questionnaire survey, user interviews and behavioral observation, this study sorted out the collected raw data and used the KJ method to card, cluster and summarize user opinions, extracted 9 key requirements in the interactive

design of children's garbage classification education, and divided the requirements into levels to form a list of requirements (see Fig. 1).

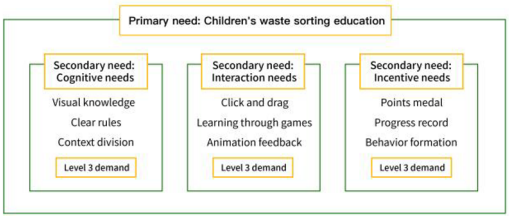

Fig. 1. Requirement list.

4 Interactive Design Strategies for Children's Waste Sorting Education

4.1 Design Principles

Based on user survey results and the cognitive characteristics of preschool children, this study proposes that the interactive design of children's waste sorting education should follow four principles: intuitive and easy to understand, fun and interactive, immediate feedback, and continuous motivation. Visual and contextualized content helps children understand sorting knowledge, gamification enhances learning interest, animation and voice provide immediate feedback, and points, badges, and growth records promote sustained participation and the formation of behavioral habits.

4.2 Service Blueprint

This study uses the service blueprint method[7] to systematically sort out the whole process of children's garbage classification learning. The service blueprint constructs a service structure from four levels: user behavior, front-end interaction, back-end support and support system, clarifies the key touchpoints and system collaboration relationships at each stage, forms a service path of "introduction-learning-operation-feedback-incentive-growth", and constructs a complete educational service closed loop, providing a basis for subsequent functional architecture design and interface design (see Fig. 2).

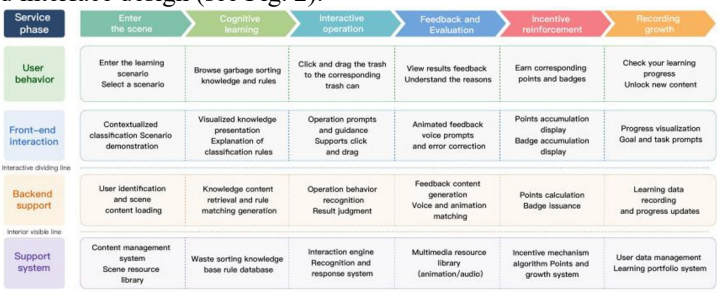

Fig. 2. Service blueprint.

4.3 Visual Design Analysis Based on Children's Cognitive Characteristics

Preschool children primarily use concrete image thinking and have limited understanding of abstract concepts. They rely more on colors, graphics, and life experiences to understand things and find it difficult to comprehend complex text and interface content with too many layers. At the same time, children are more likely to pay attention to brightly colored, vivid, and interesting visual elements. Therefore, the garbage classification education interface should adopt an intuitive, simple, and fun design approach. Through clear color distinctions, cartoon graphics, life-like scenes, and clear layout hierarchy, it can help children quickly understand information, complete operations, and improve learning efficiency and user experience.

5 Interactive Design Practice for Children's Waste Sorting Education

Guided by design principles, service blueprints, and visual analysis, this study completed the design of a children's waste sorting education app, which mainly includes four core interfaces: situational sorting, sorting practice, learning records, and my rewards. The overall design uses green as the main color, combined with rounded cards, cartoon illustrations, and large icons to create a friendly and lively visual style, helping children quickly identify information and complete operations. The four interfaces are interconnected, forming a learning path of "situational cognition—interactive practice—growth records—incentive reinforcement," enhancing the fun, sustainability, and behavioral development effectiveness of waste sorting education (see Fig.3).

Fig. 3. Children's waste sorting education interface design.

6 Conclusion

This study, focusing on preschool children, deeply integrates sustainable design principles into the entire process of interactive waste sorting design. Through multi-dimensional user research and the KJ method to identify core needs, it constructs an integrated design framework centered on contextual guidance, hands-on interaction, immediate incentives, and behavioral reinforcement. The study clarifies the application path of sustainable design in children's environmental education: based on ecological awareness, centered on behavioral guidance, and aiming for long-term habit formation, achieving a closed loop from knowledge transfer to habit shaping. Compared with existing interactive waste sorting results for children, this study strength-

ens the deep integration of sustainability and education, addressing the problems of similar designs that emphasize fun but neglect habit formation and sustainability. The research results put sustainable design from a conceptual level into practice in children's educational interactive design and also provide new ideas for the innovative application of sustainable design principles in art and design.

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