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Designing Social Integration Products for Children with Autism Spectrum Disorder

-- A KANO Model-Based Approach

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Abstract: Children with autism spectrum disorder (ASD) often have difficulty participating in the social life of the school, and most of the current intervention tools are based on structured training environments and may not meet the needs of daily social interaction. Therefore, in this paper, a Design Approach for social inclusion products is proposed based on the KANO model in a user-centric Design system. Semi-structured interviews and field observations were carried out to explore the initial needs of children with ASD, their parents and special education teachers, and from them, 19 essential requirements were identified. Further analysis of the demand was conducted using the KANO model and Better-Worse coefficient analysis; thus, they were divided into 'must-be', 'one-dimensional' and 'attractive' categories, and corresponding design priorities were determined. Safety and convenience are the basic requirements; therefore, many users have been satisfied by the added functions of multiple-person interaction and cooperative task guidance. Based on the above analysis, a functional framework of situational projection, social guidance and incentive feedback was constructed, and then prototypes were developed and tested with the target group. According to the results of the evaluation, the prototype has helped develop the social skills of children with ASD and is suitable for application in inclusive classrooms. In short, this study has used the KANO model to transform various user needs into practical design demands and provided a methodological path for inclusive product development in special education.

Keywords: Autism spectrum disorder; KANO model; User-centered design; Social participation; Product design.

1. Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that affects social communication and interaction, has limited language skills, and shows repetitive behaviours. People with ASD are also more likely to have abnormal sensory processing and problems of attention regulation [1]. Epidemiological research shows that the world's prevalence of ASD is about 1 in 127 people, and this proportion has been increasing over time. A long-standing problem in the social adaptation and all-round development of children with ASD is a deficit in social skills [2]. Recently, many interventions to improve the social skills of children with ASD have appeared, such as peer-mediated interventions, pivotal response training and naturalistic behaviour interventions [3].

With the development of digital technology, social robots, virtual reality environments and gamified systems for autism spectrum disorder (ASD) intervention have emerged. However, most of the existing research focuses on structured training environments and has paid relatively little attention to product-oriented design solutions for social interaction in daily life. Given the social behaviour traits and usage demands of children with ASD, a user-centred Design approach is used in this study to conduct requirement analysis based on the KANO model and explore a product design path that integrates social-situational training with gamified interaction. The goal of this paper is to boost the children's interest in socialisation and provide a feasible design plan for promoting their self-initiated participation in daily life.

2. Research Status of Intervention Product Design for Children with ASD

With the development of inclusive education, more and more children with autism spectrum disorder are now being educated in general education schools. However, these children often have limited participation in class, shorter durations of interaction, and difficulties integrating socially due to challenges in understanding social cues, slower interactive responses, and problems with emotional regulation during class communication, group work, and interactions with peers [4]. The above problems indicate that the intervention methods for helping children with ASD participate more actively in inclusive education are still mainly function-oriented and fragmented. A system design framework that meets the demands of a real-life social interaction scenario has not been published. Recently, the Design of intervention products for children with ASD has become a focus of research at the intersection of design studies and special education. Most research in China to date has focused on sensory regulation, emotional regulation and cognitive-behavioural therapy. Previously, research has investigated multiple ways to engage the senses for emotional regulation and awareness in children with autism spectrum disorder (ASD) [5], and other studies have employed interactive devices that use music and light feedback to help children identify emotions and manage their emotions [6].

Gamified product design has also been introduced to support cognitive and behavioural training [7]; although these studies have provided individual-level interventions, they have mainly focused on solitary training and emotional regulation. Therefore, actual social interaction situations have

received relatively little attention. Research abroad has also recently begun to focus on fostering social skills, and at the same time, many scholars have started to explore how to enhance these abilities. Kaspar is a social robot that creates an organised social training environment through emotional expressions, tactile feedback and interactive games, and QTrobot supports user engagement in continuous teaching programs and highly interactive content. However, these systems have only been used in training environments so far and have not been fully implemented in daily life. Research has not yet systematically studied the Design of authentic peer interaction in daily life.

3. Research Methods and Procedures

3.1. Research Methods

User-centred Design (UCD) has moved the focus of Design from experience-driven decision-making to user-oriented development. Based on empirical studies, cognitive features, behaviour and emotional requirements of users are explored to inform the Design Standards for intervention products [8]. Under the umbrella of user-centred design (UCD), behavioural traits and demands can be integrated at all stages of the Design process to improve user satisfaction and efficiency. Children with autism spectrum disorder (ASD) have differences in sensory processing, emotional recognition and social interaction compared to typically developing children, so intervention products that consider these cognitive differences are more likely to meet the actual needs of users and improve the effectiveness of intervention [9].

Noriaki Kano first put forward the Kano model in 1984 to classify and analyze all kinds of user demands [10]. Given the quality attributes and their effects on user satisfaction, five categories of user requirements have been identified in the model. Must-have requirements (M) are the basic attributes or functions of a product that users need. The above conditions will not significantly enhance the users' satisfaction, or there will be a considerable decline in it. One-dimensional requirements (O) are attributes that users can explicitly expect and easily recognise. Therefore, according to the above requirements, the satisfaction of users will be improved; otherwise, it will decrease. Attractive Requirements (A) are attributes that users did not expect but were pleased or satisfied to find; they can significantly enhance the user experience and make the product more attractive. However, in their absence, a drop in user satisfaction will not be observed. Indifferent requirements (I) are features that users are not overly concerned about; therefore, it does not matter whether they are provided or not for the general satisfaction of the system. Reverse requirements (R) are cases in which different users have different demands for the same function, and thus providing a particular function may reduce the satisfaction of some user groups.

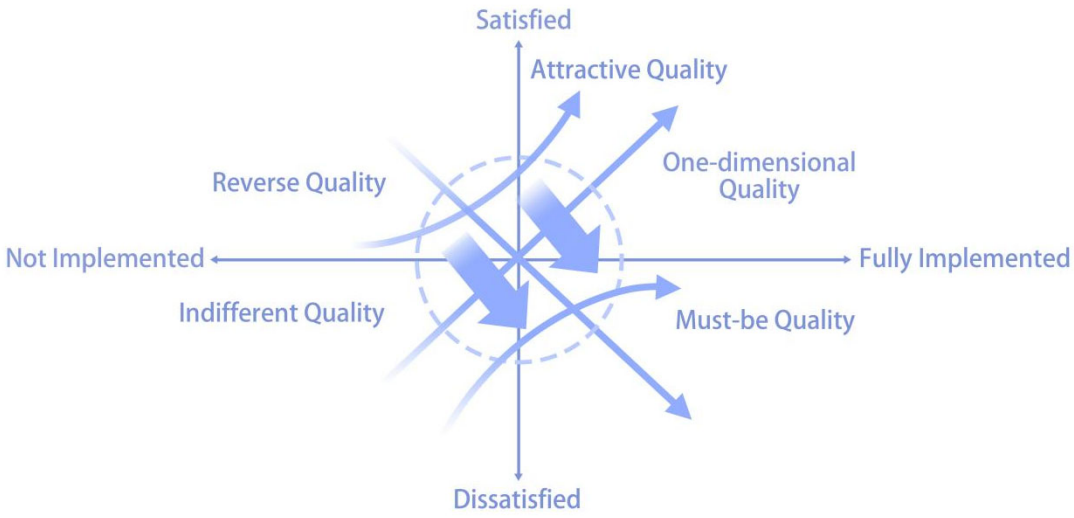


Figure 1. KANO Model

Recently, many areas of healthcare and product design have been studying under the KANO model. Duan Pei and others [11] have recently used the KANO model to classify and analyze the needs of patients with allergic rhinitis treated by traditional Chinese medicine nebulisation therapy, and determined how different types of needs affect user satisfaction to improve the patient experience of this treatment. Hu Jianying and others [12] applied the KANO model to classify and identify the demands that older adults have for memory support, health reminders and safety assurance, established connections among these demands and user satisfaction, and thus provided a foundation for designing functional structures and interaction strategies of elderly memory-assistance products. Based on the above research, the KANO model can be used to identify different levels of demand for the new generation of social intervention products for children with autism spectrum disorder (ASD) and help in designing these products. Thus, we will know how the basic functions and performance-related attributes are related to the experience-oriented features, and obtain some quantitative data for the design strategy.

3.2. Research Procedure

Given the demand for social participation by children with ASD in inclusive education settings, this paper has established a framework to design a social intervention product based on User-Centered Design and the KANO model. The four steps of the research process and their contents are shown in Figure 2 below.

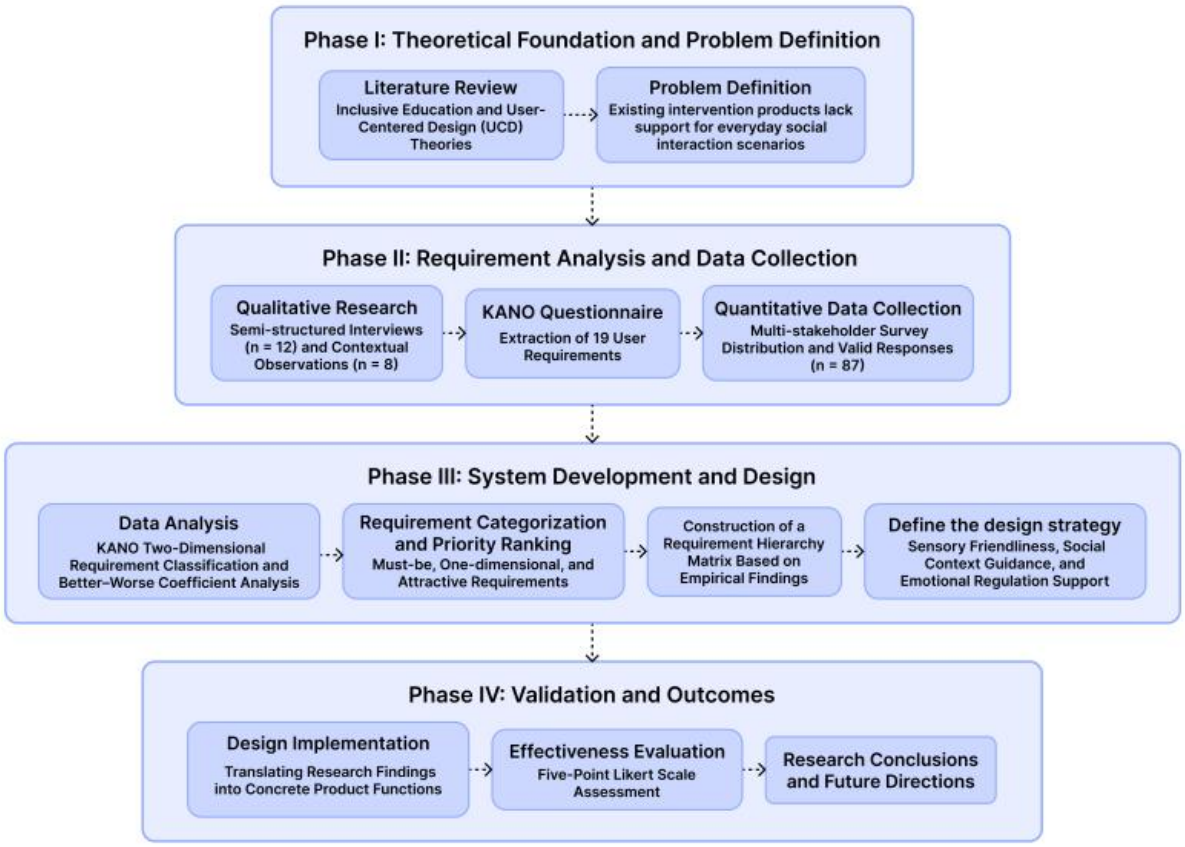


Figure 2. Flowchart of Social Integration-Oriented Product Design Research

4. User Requirement Identification Based on the KANO Model

4.1. User Research

4.1.1. Psychological and Physiological Traits of Special Education Teachers.

Support for the social inclusion of children with autism spectrum disorder in inclusive education environments is adding more pressure to special education teachers. The person is constantly under psychological stress and easily exhausted. As the indispensable facilitators of inclusive classrooms, special education teachers are required to promote the social participation of children with ASD and manage the routine teaching of typically developing children simultaneously; thus, they bear a dual-role burden and an increased workload. Therefore, teachers have begun to want intervention devices that are less intrusive but can still achieve good intervention results. Many of the teachers' attention and energy in their daily teaching and behaviour-modification activities are spent on continuous behaviour observation, repeated verbal prompting and regulation of peer interactions. Gradually, the above responsibilities will cause physical exhaustion and occupational burnout. Intervention products with automatic guidance mechanisms can reduce the supervision requirements and increase teachers' sense of efficacy and usability of these products [13].

4.1.2. User Personas

In the early days of the Design research, some primary users' experiences under different circumstances were explored through narrative analysis. These users mainly included special education teachers who have communication difficulties with inclusive classrooms and parents of children with ASD who bear significant caregiving and rehabilitation responsibilities. Both groups require a significant investment of time and attention for daily educational support and behaviour management. Based on real user data, user personas were created to provide a foundation for the development of social-welfare intervention products. First, twelve main parties were selected for interviews and contextual observations to collect demographic information and behavioural traits. Then, the users were divided into several groups to learn about the problems and wishes they had for inclusive education and family life. Finally, user personas were created and applied to suggest some first-level functions of the product, as shown in Table 1.

4.2. User Requirement Analysis Based on the KANO Model

4.2.1. Research Content

Nineteen necessary conditions for ASD social intervention products have been identified through semi-structured interviews, contextual observation and questionnaire surveys. The above demands were then organised into four categories: experience, emotion, function and safety. Given the developmental characteristics of children with ASD, special education teachers and parents were selected as the main subjects of the study, and other family members involved in childcare were also included for supplementary observations. A total of 103 target users were selected as the subjects for the KANO survey and collected online and offline. The five options for the questionnaire items were: Like, Must-be, Neutral, Live with, and Dislike; [14]

Table 1. User Portrayals

	Children with ASD	Special Education Teachers
User Persona	a:In everyday school environments, atypical sensory processing may cause children to become overwhelmed by intense lighting or environmental noise, resulting in spatial avoidance and anxiety. b:Influenced by emotional fluctuations and cognitive challenges, children often demonstrate deficits in joint attention and encounter difficulties interpreting peers' social cues. c:During dynamic social interactions, delayed responses are frequently observed.In some cases, children may actively avoid participation by withdrawing or hiding from social situations.	a:Teachers are responsible for maintaining routine classroom instruction for all students while ensuring the smooth operation of inclusive educational activities. b:They must continuously monitor the behaviors and emotional states of children with ASD during collaborative learning and free-play activities. c:Teachers frequently provide verbal prompts, behavioral corrections, and mediation of interpersonal interactions.
Pain Points	Existing intervention products often rely on single-user interaction paradigms and provide limited opportunities for peer engagement.	Existing intervention devices often increase supervisory demands and further fragment teachers' attention resources.
User Needs	Products should be compatible with educational settings and facilitate collaborative interpersonal interactions. Products should establish both physical and psychological safety boundaries to support social integration. Interaction modalities should extend beyond conventional human–computer interaction and incorporate diverse forms of social engagement.	Products should be seamlessly integrated into routine classroom activities. Products should provide autonomous guidance functions that reduce teacher intervention requirements. Intervention outcomes should be visualized to facilitate evaluation and progress tracking.
Product Hypothesis	The proposed product employs projection-based interaction and gamification mechanisms to establish a lightweight social guidance system that can be naturally embedded within classroom environments.By reducing teachers' intervention burden, the system aims to support children with ASD in gradually developing safe, engaging, and meaningful peer interaction experiences.	

Table 2. Requirement Items

ID	Requirement Item	Academic Requirement Description
R01	Sensory Friendliness	Soft and comfortable materials combined with adjustable lighting and sound intensity
R02	Ease of Operation	Intuitive operation that enables children to understand and use the product with ease.
R03	Clear Visual Feedback	Clear presentation of interaction outcomes through visual feedback, including images and lighting effects.
R04	Gentle Auditory Feedback	Moderate-volume auditory feedback with soft and non-disruptive sound characteristics.
R05	Rich Tactile Experience	Various tactile materials combined with vibration feedback to facilitate sensory exploration.
R06	Social Context Prompting	Visual and auditory prompts to support children's understanding of social situations.
R07	Collaborative Task Guidance	Cooperative game tasks involving participation from two or more children.
R08	Turn-Taking Mechanism Design	Clear turn-taking rules supporting waiting and reciprocal interaction behaviors.
R09	Emotion Recognition Training	Activities supporting the recognition and interpretation of others' emotions through facial expressions and contextual cues.
R10	Emotional Regulation Support	Comforting feedback mechanisms supporting children's emotional regulation.
R11	Social Reward Mechanism	Positive reinforcement strategies to enhance social motivation following task completion.
R12	Multi-user Interaction Support	Support for simultaneous participation among multiple children.
R13	Adaptive Difficulty Adjustment	Automatic adjustment of task difficulty based on children's ability levels.
R14	Usage Data Recording	Recording of behavioral data and developmental progress for teachers and parents.
R15	Portability	Appropriate size and portability for use across multiple settings.
R16	Ease of Cleaning and Maintenance	Materials that are easy to clean and disinfect.
R17	Safety Assurance	Non-toxic materials, rounded structures, and safe product construction.
R18	Parent-side Monitoring	Mobile application support for parental monitoring and parameter adjustment.
R19	Compatibility with Educational Themes	Integration with educational themes and classroom learning content.

4.2.2. Results of KANO Analysis

A total of 103 questionnaires were distributed, and after excluding the invalid ones due to missing or inconsistent answers, 87 were deemed valid; according to the KANO model, requirements R01-R19 were divided into different categories, and both the Satisfaction Index (SI) and

Dissatisfaction Index (DSI) were calculated, as shown in Table 3.

Then, coefficient analysis was performed to determine how much and in what way each requirement changed. A ranked list of the users' requirements has been prepared. The absolute values of the Better-Worse scores for the 19 requirements were determined by the Better-Worse coefficients. After secondary sorting, the coordinate diagram of the requirement sensitivity matrix was drawn, as shown in Figure 3. Using the Better coefficient as the horizontal axis and the absolute value of the Worse coefficient as the vertical axis, a requirement priority matrix was constructed. All the requirements were mapped to the four quadrants, and these datasets had different weights [15].

4.2.3. Requirement Prioritisation and Interpretation

As a result, five of the 19 requirements have been identified as essential conditions: safety guarantee, ease of use, sensory friendliness, portability and simple cleaning and maintenance. The four requirements were designated as one-dimensional demands: clear visual prompts, soft sound cues, emotional-recognition training and social-reward mechanisms. Six were selected as desirable attributes: social context prompting, cooperative task guidance, emotional-regulation support and multi-user interaction capabilities. The other four requirements were considered to be minor attributes, such as compatibility with educational themes, usage data logging, parent-side monitoring and adaptive difficulty adjustment.

Table 3. KANO Classification Results

ID	Requirement	A	O	M	I	R	Q	Category	Better	Worse
R01	Sensory Friendliness	12	8	52	15	0	0	M	0.23	-0.69
R02	Ease of Operation	9	11	48	19	0	0	M	0.23	-0.68
R03	Clear Visual Feedback	15	42	18	12	0	0	O	0.66	-0.69
R04	Gentle Auditory Feedback	22	38	14	13	0	0	O	0.69	-0.60
R05	Rich Tactile Experience	45	18	8	16	0	0	A	0.72	-0.30
R06	Social Context Prompting	38	29	7	13	0	0	A	0.77	-0.41
R07	Collaborative Task Guidance	41	26	6	14	0	0	A	0.77	-0.37
R08	Turn-Taking Mechanism Design	32	35	9	11	0	0	O	0.77	-0.51
R09	Emotion Recognition Training	28	31	8	20	0	0	O	0.68	-0.45
R10	Emotional Regulation Support	36	22	11	18	0	0	A	0.67	-0.38
R11	Social Reward Mechanism	24	40	12	11	0	0	O	0.74	-0.60
R12	Multi-user Interaction Support	43	21	7	16	0	0	A	0.74	-0.32
R13	Adaptive Difficulty Adjustment	18	15	9	45	0	0	I	0.38	-0.28
R14	Usage Data Recording	14	17	8	48	0	0	I	0.36	-0.29
R15	Portability	8	12	41	26	0	0	M	0.23	-0.61
R16	Ease of Cleaning and Maintenance	10	9	44	24	0	0	M	0.22	-0.61
R17	Safety Assurance	5	7	68	7	0	0	M	0.14	-0.86
R18	Parent-side Monitoring	16	13	7	51	0	0	I	0.33	-0.23
R19	Compatibility with Educational Themes	21	19	6	41	0	0	I	0.46	-0.29

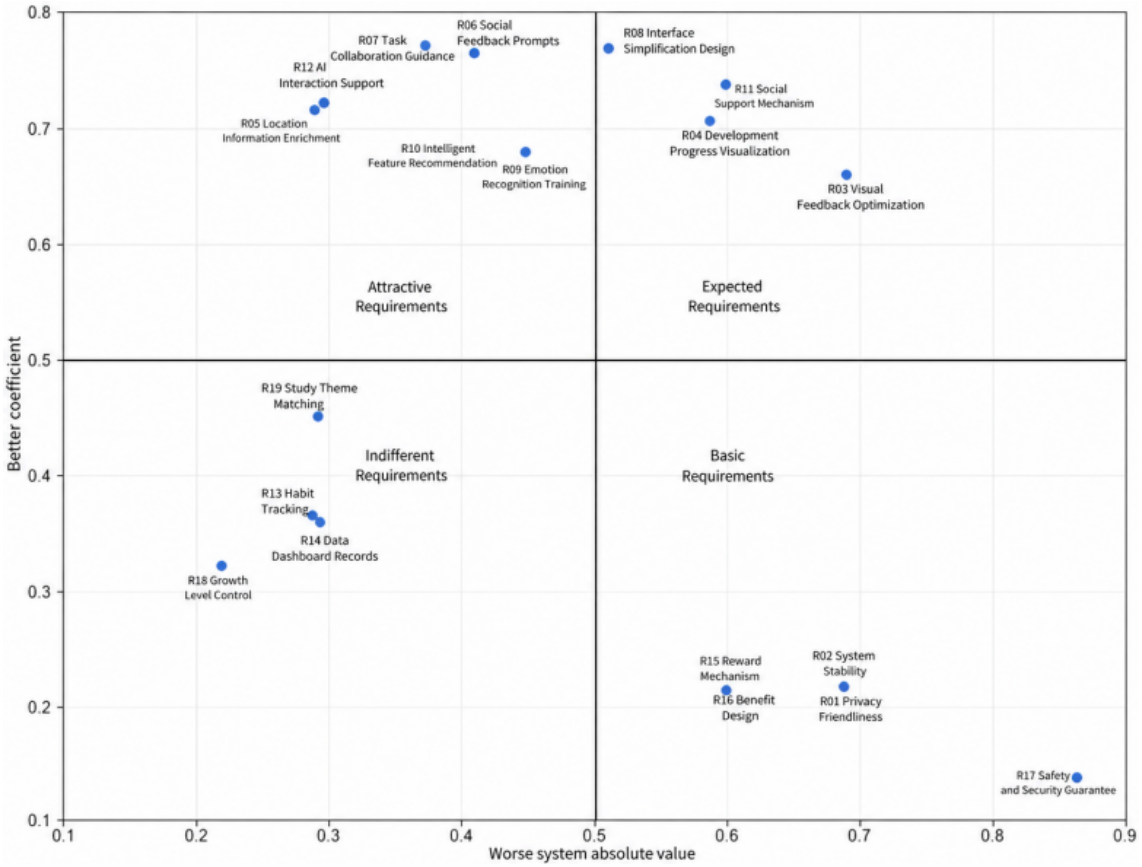


Figure 3. Better–Worse Coefficient Analysis

The ranking of priority determined by KANO analysis is used as the Design Basis. Must-have requirements are the basic conditions that need to be met for the product to be accepted; therefore, they should meet the requirements reasonably well to ensure usability and user trust. Continuously optimise the first-level requirements and enhance the performance of these requirements to meet the needs of users better. Attractive Requirements are not strictly necessary; otherwise, there would be no reason to differentiate the product and no motivation for design innovation. Indifferent requirements can be given a lower priority to reduce unnecessary development, and reverse requirements should be considered carefully in terms of the features and expectations of all user groups before being included in the design.

Based on the above priorities, the Design Strategy will ensure the basic safety and convenience of users, and add a social reward and feedback function in response to their explicit demands. Add a function for collaboration and multiple-person operation to improve the user experience and add more value. Therefore, the development work will focus on functions that are likely to enhance users' satisfaction and the effectiveness of products in inclusive education.

5. Design Practice of Social Integration Intervention Products

5.1. Design Positioning

Based on the analysis of the Kano model, nineteen design requirements for social intervention products have been identified, such as safety guarantee, ease of use, collaborative task guidance and appealing contextual interaction. Based on the priority ranking of user requirements, the social intervention product proposed here has been designed to meet the needs of the target users. Matrix mapping of the Better-Worse coefficients was conducted to identify the most representative and influential user requirements, which were then aggregated into the three main design attributes of sensory friendliness, social context guidance and emotional regulation support.

Sensory-friendly Design refers to a Design approach that considers the multiple sensory features of children with autism spectrum disorder (ASD) [16]. Both the main device and the modular building-block components are low-stimulation in terms of sight, sound and smell. Sensory overload can be reduced by using a low-saturation colour system, anti-glare projection technology, soft low-frequency soundscapes and non-irritating materials. Both the main device and the modular building-block components are low-stimulation in terms of sight, sound and smell.

The above will reduce the sense of stress and possible over-stimulation. Tactile and Proprioceptive Sensation: To make it more comfortable to hold, the shape of this product is relatively smooth and round. A reasonable Resistance in operation will generate a sense of inertia and is thus more practical. Together, the above Design considerations can create a safe, comfortable and environmentally friendly sensory space. Build interactive scenarios to offer social-contextual learning opportunities for children with autism spectrum disorder (ASD). The device can display children-friendly and dynamic visual symbols on the table surface to present abstract social rules in an intuitive and contextual way through animation. Modular Building Blocks are physical mediators that help children cooperate in play.

Children engage in cooperative activities through embodied play to develop a sense of space and prosocial behaviour. The above interactions motivate them to participate in some real-life social activities. Design mechanisms are used to reduce anxiety and provide positive emotional reinforcement through emotion regulation; a low-stress visual environment is created by modifying the colour system of a projection system. A therapeutic colour system with high brightness and low saturation is employed to promote emotional regulation, and soft light-and-shadow effects are used to reduce psychological stress. The building-block components have rounded, gentle and familiar shapes, add a soft vibration and heat-response function, and are easy to touch. Together, these components form a whole-around multi-sensory emotional-regulation system of sight, sound and touch.

5.2. Design Case Presentation

The product proposed is a social intervention system for children with autism spectrum disorder aged three to eight years old. A smart end device with multiple interactive functions can help children who have difficulty communicating with others in a social situation. Organised cooperative activities will be used to help children develop a sense of place and participate in socialisation. Embedded emotional support facilities can help promote pro-social behaviour by people.

The new product is a social-intervention system for children with ASD aged 3-8 years, and it includes an intelligent terminal and interactive modules. Organise embodied cooperative activities in the system to help children strengthen their sense of space and encourage prosocial behaviour through positive emotional reinforcement, thus improving their social skills and overall well-being. Inspired by spacecraft and UFOs, this product will not be a typical aid for the elderly and will be more appealing to use. Morandi-style colours have low saturation, such as light blue and off-white; they are warm and relaxing to the eye, and geometric building blocks are also employed. A central terminal and peripheral modules have been designed to be easy for children to hold and connect. Tabletop Interaction is shown on a terminal as dynamic visuals, and the building blocks react to this projected information in real time; thus, it combines physical manipulation with digital interaction to promote social participation and cooperative play, as shown in Figure 5.



Figure 4. Display of Social Intervention Products



Figure 5. Usage Scenarios

5.3. Design Evaluation

Based on the Design Plan, a questionnaire was distributed to learn about the convenience and effectiveness of the KANO model-based social integration intervention product for children with ASD in daily life. The four contents of the questionnaire are as follows.

First, it is an index of user experience satisfaction; specifically, how well the basic requirements for this satisfaction have been met includes sensory pleasantness, ease of operation and clear visual feedback. The indicators of emotional satisfaction are training in emotion recognition, support for emotional regulation and a social reward system. Functionality assessment will also be used to check if the cooperative task guidance, turn-taking mechanism, multi-user support and adaptive difficulty adjustment functions work correctly. In addition, the requirements for safety have also considered the convenience of cleaning and maintenance, safety guarantees and parental supervision.

Via an online survey platform, questionnaires were distributed to 20 parents and special education teachers of children with ASD aged 3-8 who are cared for and educated at home. Ten professional designers also participated in the evaluation and provided design-oriented views. Before completing the questionnaire, the participants had studied the detailed Design renderings and other introductory materials. The five levels of the Likert scale for measuring user satisfaction were: Very Satisfied, Satisfied, Neutral, Dissatisfied and Very Dissatisfied; these were assigned scores of 5 to 1, respectively, and the corresponding data are shown in Table 4.

Table 4. Example of Evaluation Questionnaire

Evaluation Item	Very Dissatisfied	Dissatisfied	Neutral	Satisfied	Very Satisfied
Emotional Regulation Support	1	2	3	4	5

Exclude the invalid responses and use the 24 valid questionnaires for the analysis. Table 5 is the evaluation results table. Satisfaction scores for both the experiential and functional dimensions exceeded 4.0, and collaborative task guidance and multi-user interaction support also received relatively high evaluations. Therefore, it is proposed that the product can help children from all backgrounds communicate in an inclusive school environment.

Although most of the evaluation items received good scores, convenience, safety guarantee and parental supervision were relatively less satisfactory, with average scores below 4.0. Therefore, we need to increase the portability and safety of the modules further. The new Design was well-received by the public and may be introduced in schools in the future.

Table 5. Design Evaluation Results

Evaluation Indicator	Mean Score	Evaluation Indicator	Mean Score	Evaluation Indicator	Mean Score	Evaluation Indicator	Mean Score
Sensory Friendliness	4.58	Emotion Recognition Training	4.33	Collaborative Task Guidance	4.63	Ease of Cleaning and Maintenance	4.33
Ease of Operation	4.42	Emotional Regulation Support	4.14	Turn-Taking Mechanism Design	4.38	Safety Assurance	3.98
Clear Visual Feedback	4.50	Social Reward Mechanism	4.46	Multi-user Interaction Support	4.50	Parent-side Monitoring	3.86
Auditory Feedback Integration	4.38			Adaptive Difficulty Adjustment	4.17		
Rich Tactile Experience	4.25			Usage Data Recording	4.21		
Convenience	3.78			Compatibility with Educational Themes	4.03		
				Social Context Prompting	4.58		

6. Conclusion

With the continuous progress of inclusive education, the market for intervention products for children with ASD is expected to be large-scale and diversified. In line with the concept of inclusive design, the social intervention products for children with ASD should also provide non-basic skill-training functions. Give more attention to creating a psychologically safe environment and helping children learn to live in society through sensory exploration and cooperative play. Based on the application of the Kano model, this study systematically identified the basic needs of children with ASD and their stakeholders, and converted requirements at all levels into feasible Design features. Then, these attributes were added to the Design and Development of a product for social integration intervention. Finally, this paper puts forward a design system consisting of the four steps listed below: analysis of users' needs, need sorting, design conversion and design verification. The study provides a way and an application for promoting research and development in the field of social intervention products for children with autism spectrum disorders (ASD). At present, the main type of requirement classification is the KANO model. In the future, embodied cognition-based evaluation methods such as eye-tracking and physiological signal monitoring may be used to provide more all-encompassing support for requirements analysis, and an objective assessment system of emotional fluctuations and joint-attention behaviour can be established in subsequent studies to offer extended methodological support for the design of intervention products. This paper investigates how to increase the participation, involvement and sense of security for children with ASD in their school and family social environments. The above framework will also boost the self-efficacy, sense of control and satisfaction of parents and special education teachers in the intervention. It can also offer a reference for the following research on inclusive product design.

At present, the requirements in this study are mainly classified by the KANO model. In the future, based on embodied cognition, eye-tracking and other physiological indicators will be used to collect empirical data for requirement analysis. The above ways can help build a more objective assessment system for emotional changes and cooperative attention in the future, provide a good reference for developing intervention products, and also show that the participation, interest and sense of safety of children with ASD in school and family social environments need to be enhanced. In addition, the above framework may help to enhance the self-efficacy and sense of control over intervention activities for parents and special education teachers. The results may also offer a reference for the next exploration of inclusive product design.

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