Design of Kindergarten Toy Lockers

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In this work, kindergarten toy storage, defined as the construction area, puzzle area, scientific observation area, and role-playing area, and the toy characteristics of the four areas, was studied. Interviews and grounded theory were used to observe and summarize the behavioral needs of 3- to 6-year-old children and preschool teachers. Analytical hierarchy process (AHP) was used to analyze behavioral needs. It was concluded that the kindergarten toy locker optimization was designed to improve storage efficiency. However, the current layout of kindergarten toy lockers is chaotic, and children cannot efficiently and autonomously take toys from toy lockers. The best toy locker layout scheme was selected through an eye tracking experiment. The subjects were all 3- to 6-year-old children, a total of 30 people. By comparing the data such as hot spot map, trajectory map, area of the first viewpoint, and gaze time when children observed different lockers layout during the experiment, the optimal layout scheme of kindergarten toy lockers was comprehensively analyzed. Optimizing the zoning, classification, and storage of kindergarten toys is conducive to improving the efficiency of children's independent storage, creating a kindergarten game and teaching environment conducive to children's development.

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INTRODUCTION

Research Background

In general, there is a lack of research on the design of kindergarten furniture, especially research that focuses on user needs and relevant research that utilizes the children's group as the conceptual research object. Published work, up to this point, not only lacks in-depth children's group face-to-face observation, but deep excavation of the real needs of the children’s group. Thus, studies cannot meet the actual needs of the target users.

In the early stage, the observation method was used to investigate the storage behavior of children. It was found that the kindergarten toy locker is the main furniture in the play area. The locker serves as a regional space division tool. While due to batch customization or procurement, the internal division of the cabinet does not provide characteristic differences, and the location of each play area is close to each other, regional characteristics that are vague do not facilitate children to play area identification, and labels should be used to for indication. Children can use this series of actions as an educational game when putting toys into correct places. However, in the process of this game, the children may not be easily able to identify complex visual information features, resulting in toy storage errors. This not only affects the experience of children's play, but it also increases the workload of preschool teachers. Therefore, it is necessary and feasible to research kindergarten toy lockers to reduce children's storage error rate and improve storage efficiency.

Research Review

Research related to user behavior and user needs

Generally, in the research process, through in-depth interviews, questionnaire surveys and behavioral observations (Village *et al*. 2015; Merbah *et al*. 2020; Konstanti *et al*. 2021), analysis of the needs of target users can be carried out to clarify the explicit and implicit needs of target users (van Liempd *et al*. 2018; Richter *et al*. 2019). If there are too many demand points, SPSS software can be used for principal component analysis or the AHP method used for weight calculation, and the main requirements of users can be determined based on the weight results, which would allow targeted design optimization (Yang *et al*. 2019; Neira-Rodado *et al*. 2020; Wang *et al*. 2021).

Grounded theory is a qualitative research method that uses systematic procedures to develop and inductively guide grounded theory for a certain phenomenon. Grounded theory contains initial encoding, focus encoding, and theoretical encoding. Zhou *et al*. (2023) used grounded theory to code and analyze the humanistic care factors to improve the design standards of intelligent elderly products and to promote the more rational use of humanistic care factors in design. Grounded theory can effectively study the needs and behavioral characteristics of target users. Cheer *et al.* (2015) have found that researchers are increasingly using grounded theory methodologies to study the professional experience of nurses and midwives.

Emotion plays an important role in the use of furniture. Through combining case study and field investigation, the user emotion can be integrated, the user’s emotional response can be identified, and the user’s emotional evaluation can be analyzed, which can enrich the research of emotional design (Cheng *et al*. 2020; Angelaki *et al*. 2022).

Research on the design of kindergarten furniture

The research-literature for kindergarten furniture is relatively small, mainly in the field of storage, sitting furniture, activity area furniture, and interior space-related design studies (Cheng *et al*. 2019). The design strategy is mainly reflected in the playful, guidance, modularity, safety, fun, growth, and emotional design methods (Purwaningrum *et al*. 2015; Gimenez *et al*. 2016). Fun and emotionality are concentrated in the color, shape, and material performance of kindergarten furniture. Safety is expressed in the stability and physiological appropriateness of kindergarten furniture. Guidance is mainly manifested in the design of storage guidance for young children. Playfulness and interest are expressed in the integration of game mechanisms and interesting elements into furniture design to increase the interaction between children and furniture. Modularity is expressed in the design of furniture that can be combined and disassembled to meet a variety of functional forms by building combinations.

Choi *et al*. (2016) presented a CMF (Color, Material, Finishing) strategy for a table in kindergarten classroom. The multi-sensory CMF strategy can deeply understand the characteristics of children's development. Through comparing the developmental characteristics of the kindergarten students with those of the CMF to derive the multi-sensory design element, the multi-sensory design elements can be obtained. Design factors derived from the development process of kindergartners are classified into keywords and used for table analysis for kindergartners.

Research on children's furniture design

Some scholars have studied children's furniture from the perspective of furniture size or furniture color. Sejdiu *et al*. (2023) obtained anthropometric data of primary school students in the Republic of Kosovo by measuring the body parts of 720 students in 12 different primary schools in four different regions of the Republic of Kosovo. Based on the study, they provided effective recommendations for school furniture design. Jiang *et al*. (2020) analyzed children's influence on furniture selection from the perspective of color preference. The study found that the influence varies with different types of furniture. In addition, children have slightly different preferences for furniture in different functional spaces, and children of different genders and ages have different choices in furniture color.

Environmentally friendly design is increasingly and widely used in the field of children's furniture design. Environmentally friendly design follows the theory of sustainable development (Tian *et al.* 2018; Peng *et al.* 2021). Such design practices recycle resources and provide a scientific basis for product rationality (Vidal *et al.* 2022). The environmentally friendly design of children's furniture has a significant impact on children's growth. Wei and Madina (2022) focused on the use of environmentally friendly materials in the design of children's furniture and combined fuzzy technology with structured design technology to build a fuzzy technology-based children's furniture design system.

In the process of emotional design, children's furniture design needs to consider the application of artificial intelligence design concept, to meet the rapid growth of children's physical and mental needs. Through discussing the necessity and design principle of the application of artificial intelligence in children's furniture from the perspectives of society, children, and development trends, it can lay a foundation for interesting and multifunctional children's furniture design (Zhang and Li 2022).

Eye tracker and furniture design

Eye tracking technology, based on human visual attention mechanism, is an objective and effective means of research and a feasible method to solve objective problems (Deng and Gao 2023). Eye movement data reflect objective indicators of human eye movement behavior and focus of attention, and each indicator has a specific meaning and scope of application (Chang *et al.* 2016). It is one of the focuses of this study to select appropriate indicators to establish the relationship between eye movement data and user morphological elements intention preference (Zhagn and Xu 2020). Through eye-tracking technology, one can extract the elements of furniture shape design, study the cognitive intention preference of shape features, and study the color preference of furniture (Xu and Zhang 2012; Liu *et al*. 2018). In the existing papers, no scholars have used eye-tracking technology to study children's toy storage furniture, so the use of eye-tracking technology to study the layout of children's toy lockers has innovative significance.

EXPERIMENTAL

Study of Objects

Kindergarten toy storage defined

According to the definition of the unitary activity in kindergarten, the classroom is the main environment for children's teaching and play activities. The classroom usually contains various types of regional activity spaces. The different activity areas are the unitary parts that constitute the overall classroom environment. Zhu (2019) summarized the views of experts and scholars in a study on the guidance strategies of kindergarten area activities, and defined area activities as areas where teachers create a reasonable teaching environment for children according to their educational goals and characteristics, and meet children's free, autonomous, and self-selected interactive operation activities by putting in play materials and intervening to guide them. Generally, they set up constructive areas, educational areas, science areas, play areas, and art areas. These areas are set with construction area, puzzle area, science area, play area, artwork area, *etc*. As shown in Table 1, there are four main activity areas where the materials are toys: construction area, puzzle area, science observation area, and role-playing area, and other activity areas where the materials are not toys, so they are not included in the present study.

Table 1. Attributes of Toys and Materials Placed in the Activity Area

Classroom Activity Area	Area Placement Materials	Is Material Placement Attribute a Toy?
Construction area	Building block toys	Yes
Puzzle area	Educational toys	Yes
Science observation area	Science exploration class toys	Yes
Role-playing area	Representational toys	Yes
Artwork area	Artwork tools and drawing materials	No
Reading area	Picture books and pictorials for young children	No
Central teaching area	Music, dance apparatus	No
Living area	Water cups, saliva towels, combs	No

Based on the above situation, toy storage in kindergarten is defined as toy material storage in construction area, educational area, scientific observation area, and role-playing area.

Kindergarten Toy Storage Features

Characteristics of toy materials in the construction area

The main development area is health-related, through the development of children's fine motor and creative imagination, the main core experience is to develop children's hand-eye coordination and organization and construction ability, to understand the nature of various construction materials, to learn the spatial relationships, to understand the concept of whole and part, and to enhance the understanding of quantity and figure. The main core experiences are aimed to promote the development of their perception and thinking, and to improve their aesthetic ability in constructing shapes.

The toys in the construction area are mainly wooden blocks, which can be divided into small blocks, medium blocks, and large blocks in terms of their size (Fig. 1).

Characteristics of toy materials in the puzzle area

The toys in the puzzle area are diverse. To ensure that children explore and discover in rich materials, enough toy materials should be put in the puzzle area, which can provide children with more opportunities to choose and effectively reduce the phenomenon that children do not use enough toys, which may result in them arguing with each other.

The toys in the puzzle area are divided into four categories: puzzles, cards, rules, and math, including pegs and stacking toys to develop children's fine motor skills; cards, including phonics cards and puzzles to develop children's reading and writing skills, and cognitive skills; tabletop games and board games to exercise children's thinking skills; and math, including graphical matching and arithmetic games to improve children's mathematical and graphical cognitive skills. To enhance children's mathematical cognition and graphics cognitive ability, the most used educational toys are puzzles, chess toys, counting toys, and literacy and phonics cards (Fig. 2).

Characteristics of toy materials in the science observation area

The toys and materials in the science observation area are mainly scientific observation instruments and props and game materials. The main developmental elements are intended to exercise children's ability to discover and solve problems and to develop and deepen scientific cognition. The number and types of toy materials are smaller compared to the educational area. The toys in the science observation area are mostly in bulk form, small in size, and difficult to calculate, and require baskets for storage. The storage for children is to observe and manipulate anytime and anywhere. The most commonly used toys in the science observation area are magnet toys and magnifying glasses (Fig. 3).

Characteristics of toy materials in the role-playing area

The toy materials in the role-playing area are mainly situational simulation toy sets and include props and materials such as simulated food and household items. The game is played by children acting out the role of different occupations, using simulated toys to simulate and restore the work or life scenes of adults, rehearsing and communicating with each other, mainly to cultivate children's social interaction and adaptability, and to exercise children's communication and expression skills (Fig. 4).

Fig. 1. Construction area

Fig. 2. Puzzle area

Fig. 3. Science observation area

Fig. 4. Role-playing area

Distribution of applicable objects of toys

Based on the requirements of preschool education for early childhood development, toys were classified into six types that can serve in the education of preschoolers and can be understood and filled by early childhood educators. One-way analysis of variance (ANOVA) was conducted using SPSSAU software (Beijing Qingsi Technology Co., Ltd., version 23.0, Beijing, China) to test and analyze whether the number of toys of each type differed across age classes. As shown in Table 2, the significance levels for all six toy categories were greater than 0.05, indicating that there was no significant difference in the number of toys in the puzzle category across age classes. This reflects that the age differences in toy manipulation among preschoolers were not significant.

Table 2. Categorization of Toys

	Build Class	Science	Language	Cognitive	Digital	Rule Class
Small Class	1.69 ± 0.86	3.00 ± 1.30	2.31 ± 1.26	2.31 ± 1.20	2.97 ± 1.36	2.91 ± 1.40
Middle Class	1.82 ± 0.92	2.42 ± 1.12	2.67 ± 1.22	2.30 ± 0.68	2.85 ± 1.30	2.64 ± 1.22
Large Class	1.68 ± 0.96	2.62 ± 1.35	2.26 ± 1.02	2.29 ± 1.00	2.62 ± 1.30	2.32 ± 1.20
F	0.249	1.757	1.172	0.848	0.606	1.731
P	0.780	0.178	0.314	0.431	0.547	0.183

Study of Human Behavior

User behavior demand research

Qualitative interviews were conducted with kindergarten teachers to understand the behavioral needs of children and teachers in the process of using toy lockers. The collected interview records were converted into text. Qualitative research methods and grounded theories were used to analyze the interview results, which were divided into three steps, namely initial coding, focused coding, and theoretical coding, to obtain the information of teacher user groups for kindergarten toy lockers.

The initial coding is the process of the primary analysis, comparison, and screening of the original interview text data to find the conceptual class, and conceptualization and labeling by extracting keywords. A total of 22 conceptual coding results were extracted from the interviews. The specific initial coding is shown in Table 3.

Focus coding is the process of transforming empirical descriptions into analytical concepts, extracting the most important or most frequently occurring concept codes for correlation, classification, and summarization, as well as merging abstract concept genera, which is a process of cluster analysis, forming main categories and sub-categories from top to bottom, and finally obtaining five main categories. These include functional improvement and optimization, appearance and styling, functional extension, operational requirements, and user experience, specifically the specific focus codes are shown in Table 4.

Table 3. The Process of Initial Encoding

Interview Text	Conceptualization
Need to create the environment of the play area, according to the theme set content of the area system layout, decorative transformation including walls, floors, locker cabinets, hanging decorations and other space layouts.	A1 Creation of play area environment A2 Game area environment creation with theme decoration
According to the teaching planning and arrangement, the thematic environment is created in a monthly or weekly cycle, and the change of the thematic content will drive the layout of the furniture in the classroom, which requires moving the locker furniture to plan and divide the space of different areas, and the frequency of change is relatively frequent.	A3 Theme changes are cyclical in nature A4 Lockers need to be moved periodically
Organize toys about once a week, reorganize toy storage locations, and separate toys that are confused.	A5 Repeatedly organize toys
To avoid toy scrambling, children are divided into groups and placed in different areas for play activities. Sometimes, aids such as playing the piano or music are used to remind children to take turns switching areas for play activities. When children are fighting for toys, the first option is to observe whether children can communicate with each other and negotiate a solution, and if not, then intervene to mediate, usually with verbal guidance.	A6 Group games A7 Regional exchange reminder
The top of the locker cabinet does not have a shield bar, placing items easy to fall.	A8 Cabinet top shelf is not blocked
Locker cross-combination placement, cross-over to produce dead ends, picking up items there are obstacles.	A9 Lockers have cross pickup dead ends
There are differences in the degree of fragmentation and volume size of young children's toy materials, in the division of storage space, you can design several layers of cabinets with compartments and several layers of cabinets without compartments, the same kind of toys on the same layer.	A10 Toy storage A11 Layered storage A12 Categorized storage A13 Storage space is well divided
During daily teaching activities, children have a short break time, so it is not convenient to play with baskets of toys.	A14 Fragmented game time A15 Standing game platform
It is generally not recommended to set up a private space for individual activities, as children are relatively scattered in the classroom, while the hidden space is easily out of the teacher's sight, and when children's activities are uncontrolled for a long time, it is easy for safety problems to occur and inconvenient to find and deal with in time, with a high safety risk factor.	A16 Intimate space security A17 Children's play activities are constrained by supervision

Interview Text	Conceptualization
Children are more interested in outdoor activities than indoor activities, so they can introduce some outdoor play facilities with low action range and low space requirements into the indoor space.	A18 Introduction of outdoor play (small range of motion, low space requirements) A19 Diversity of game styles
Know about smart small appliances (such as refrigerators), but do not know much about smart storage. It only provides some guidance instructions, it is not very necessary, and it is not very applicable to kindergarteners.	A20 Focus on the applicability of intelligent furniture in kindergartens
A simple understanding of the interaction, but worried about whether children can quickly get up and running when it comes to concrete implementation, and whether there are safety hazards (the presence of electricity, *etc.*).	A21 Focus on security and ease of use of furniture interaction
Each compartment of the locker is labeled with a corresponding label for toy storage guidance, but because there are many different kinds of toys and the layout of the storage compartment is confusing, it takes a long time to find the label that corresponds to the toy, so many children are reluctant to follow the label tips to pick and place.	A22 Storage partition layout clear

Table 4. The Process of Focus Encoding

Main Category	Sub-categories	Concept Scope
Functional improvements and optimizations	Improve storage efficiency	A5, A11, A12, A22
	Openness of space	A8, A13
	Improving space utilization	A9
Appearance	Game area identification	A1
	Theme decorative	A2
Functional extensions	Improving the fun	A18, A19
	Providing operating platform	A14, A15
Operation requirements	Mobile Convenience	A3, A4, A10
	Game area division	A6, A7
Use experience	Space security	A16, A17, A20
	Interactive ease of operation	A21

The theoretical encoding was completed by further integrating and condensing the conceptual categories coded in the first two stages to form the core category, with the core content being user needs. The interview data of the two interviewed users set aside were tested for saturation around the theory of user needs. No new initial conceptual categories or new relational links emerged during the coding process, so it was determined that the theory had reached saturation, and the primary and secondary categories were more complete. All category classes were logically concatenated to create a theoretical analysis model of user needs, as shown in Table 5.

Table 5. Influencing Factors of User Needs

User requirements (A)	Exterior styling (B_1)	Game area identification (C_1)
		Theme Decorative (C_2)
	Functional improvements and optimizations (B_2)	Improve storage efficiency (C_3)
		Spatial openness (C_4)
		Improve space utilization (C_5)
	Operational requirements (B_3)	Mobile portability (C_6)
		Game area division (C_7)
	Functional expansion (B_4)	Provide operating platform (C_8)
		Improving interest (C_9)
	Use experience (B_5)	Space security (C_{10})
		Interactive ease of use (C_{11})

User behavior demand weighting analysis

The AHP is a system analysis method for evaluation and decision-making, which has the characteristics of combining qualitative and quantitative items. It can make a clear evaluation of fuzzy and difficult-to-quantify problems (Cui *et al.* 2022). Through establishing a fuzzy consistent judgment matrix through pairwise comparison of elements, the qualitative indexes are converted into quantitative data, the comprehensive weights of each element are calculated, and the different requirements are prioritized to provide an objective scientific theoretical basis for design.

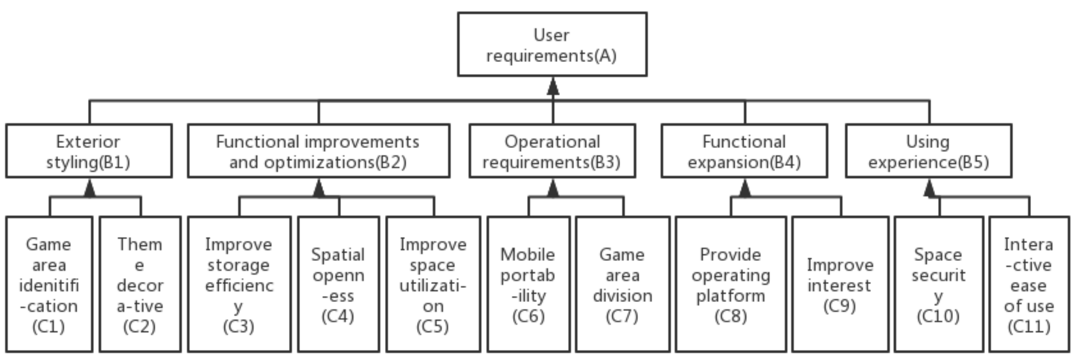


Fig. 5. Analytic hierarchy model

The corresponding hierarchical analysis model (Fig. 5) was constructed by combining the interview user demand influence factor model, including the target layer, the criterion layer (5 elements), and the indicator layer (11 elements), and then the interview user demand influence factor model was constructed into a comparison matrix Y.

$$Y = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ y_{n1} & y_{n2} & \cdots & y_{nn} \end{bmatrix}$$

In the matrix Y, y_{ij} (i = 1,2,...,n;j = 1,2,...,n;n = 11) is the important judgment of element i compared with element j, $y = B_{iji} : B_j$, then $y_{ji} = 1/y_{ij}$. $y_{ij} = B_i : B_j$, then y_{ji} =

$1/y_{ij}$. Let the maximum characteristic root of the judgment matrix be λ_{max}, and the normalized eigenvector of each element be the weight W. According to the 9-level scale method of judgment matrix elements for the relative importance of paired elements, five experts were invited to form an evaluation team to judge the elements of each level in pairs, construct the judgment matrix of each level index, and use SPSS to calculate the weight value of all evaluation indexes as Guideline layer:

$$W_A = \begin{bmatrix} 0.1255 & 0.4321 & 0.1327 & 0.2365 & 0.0731 \end{bmatrix}$$

Indicator layer:

$$W_1 = \begin{bmatrix} 0.0837 & 0.0418 \end{bmatrix}$$

$$W_2 = \begin{bmatrix} 0.2801 & 0.0992 & 0.0527 \end{bmatrix}$$

$$W_3 = \begin{bmatrix} 0.0885 & 0.0442 \end{bmatrix}$$

$$W_4 = \begin{bmatrix} 0.0591 & 0.1774 \end{bmatrix}$$

$$W_5 = \begin{bmatrix} 0.0488 & 0.0244 \end{bmatrix}$$

The CR values of the target and criterion layers are less than 0.1, which means that the matrix Y meets the requirements through the consistency test, so the combination weight W can be used as the basis for decision-making. In the criterion layer, function improvement and optimization (0.4321) > function expansion (0.2365) > operation requirement (0.1327) > appearance modeling (0.1255) > using experience (0.0731); in the index layer, the top five elements in order of importance are improving storage efficiency (0.2801), improving fun (0.1774), openness of space (0.0992), ease of movement (0.0885), and play area identification (0.0837). To make the design goal clear, this kindergarten toy locker optimization is designed to improve storage efficiency.

Locker optimization design

Combined with the above research on the toy storage characteristics of kindergarten toys, among the four activity areas where the materials put in are toy attributes, the toy characteristics of the role-playing area differ significantly from those of the other three areas, and the toys in the role-playing area have little impact on the overall storage efficiency of children in the process of storing toys. The study was conducted in the three other areas (puzzle area, construction area, and science observation area). The puzzle area contains four kinds of toys: puzzles, chess toys, counting toys, and phonics cards; the construction area contains two kinds of toys: small blocks and large blocks; the science area contains two kinds of toys: magnet toys and magnifying glasses.

To adapt to the standardization and automation of the production of kindergarten furniture products, the variability of the internal dimensions of the lockers should be minimized, so the lockers are divided into 4 layers, where each layer has 6 grids of the same size. The internal grid of the locker is 350 mm long, 300 mm high, and 430 mm deep. The overall length of the locker is 2226 mm, the overall width is 450 mm, and the overall height is 1300 mm.

The lockers are partitioned by color, and the matching choice of color and toy area, combined with the questionnaire and color semantics, results in the original wood color representing the construction area, accounting for 6 grids; yellow representing the puzzle area, accounting for 12 grids; and blue representing the science area, accounting for 6 grids.

Eye Movement Experiment

Purpose of the experiment

The eye-tracking device was used to capture the subjects' eye-movement data when observing the experimental pictures. The representational data when interpreting the subjects' information was collected in each region using the division of interest zones. The authors analyzed the presentation of the subjects' visual information in different locker division layouts to determine the subjects' eye-movement gaze sequence pattern, visual field distribution, and information acquisition difficulty. After the eye-movement experiment, the locker layout with the highest storage efficiency was inferred based on the eye-movement data results to optimize the locker design.

Subject selection and experimental preparation

The subjects were all young children aged 3 to 6 years old, 30 in total. There were 13 boys and 17 girls. All subjects were asked about their experience with kindergarten toy lockers and had some knowledge of the product features. The subjects' visual acuity was above 1.0 with bare eyes or corrected eyes and no astigmatism. The subjects were trained before the start of the experiment and were able to successfully complete the eye-movement data capture. The experiment was conducted using a Tobii Pro Fusion telemetric oculometer (Tobii Pro Fusion, Tobii, Stockholm, Sweden) with a sampling frequency of 250 Hz and Ergolab eye-tracking software (KingFar International Inc, version: 3.17.2, Beijing, China), which consists of an experimental design module, an eye capture module, a recording module, control software, and data analysis software to obtain natural eye-movement behavior data. There were no visual and auditory interference factors during the eye movement experiment to ensure the accuracy of the eye movement experiment.

Experimental steps

Before the formal experiment began, the staff introduced the basic situation of the kindergarten toy locker and the experimental procedure to the subjects and assigned the experimental task. The experimental task was: after each picture of the toy locker appeared, read every label on the locker according to their own eye-movement habits, and try to read the same labels together (the label colors were unified to reduce the impact of the differences between the labels on the subjects' vision). After each picture, click the left mouse button to switch to the next one automatically.

There were three groups of pictures as follows: the first group had only one locker picture without color differentiated layout; the second group had 13 locker pictures with different layouts, all using original wood, and were yellow and blue for differentiation; the third group also had 13 locker pictures with different layouts, but their layouts corresponded to the second group one by one, and the colors were further subdivided by shades of hues. Each layout case of the second and third groups was set up with the corresponding AOI (Automated Optical Inspection) interest area according to the type of toys (puzzle, construction, or science).

The above experimental procedure was repeated for each subject until the end of all samples played. The eye-movement experimental data were considered valid if the subjects did not feel obvious fatigue during the experiment. The experimental equipment and field conditions are shown in Fig. 6.

Fig. 6. Experimental site

RESULTS

Layout Rationality Analysis

Table 6 shows the hot spot map and the trajectory map of the eye tracking experiment above. Table 7 shows the area of the first viewing point of the eye tracking experiment above.

(1) Hotspot diagrams were used to observe the attention distribution of the subjects. The hotspot map is a common representation of eye-movement data, which can visually reflect the subjects’ attention to each locker grid. The red area of the hotspot map indicates the most concentrated area of browsing and gazing, and the larger the area indicates the more focused the subject's vision. The longer the subject spends in a certain area of interest, the stronger the intentional preference for that storage area, and the increase in feedback time leads to a darker color of the hotspot map (Liang *et al*. 2022).

The comprehensive analysis of the color shades and area size of each group of pictures showed that the subjects’ visual field was more concentrated in the middle and upper part of the cabinet, and the observation time was shorter at the sides and bottom of the cabinet.

(2) The eye-tracking diagram was used to obtain the subjects’ tendency of browsing order (Niu and Huang 2022). Most of the subjects focused their first sight on the center and upper area of the interface, and then scanned each tab one by one, resulting in a “Z”-shaped scanning result. However, the stepped and T-shaped layout will affect the scanning results; some more complex layouts will increase the sequence and repeat the areas already seen.

Table 6. Experimental Hot Spot Map and Trajectory Map

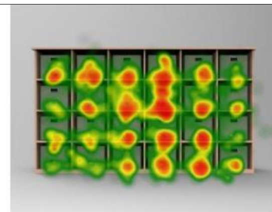
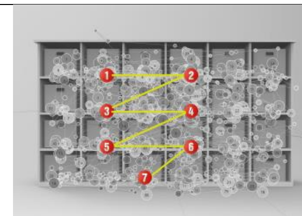
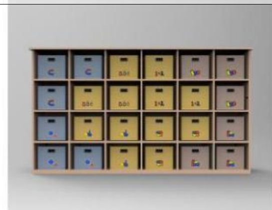
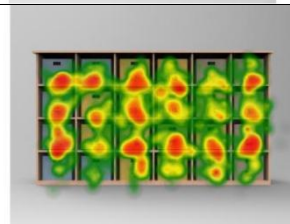
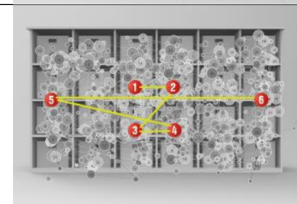
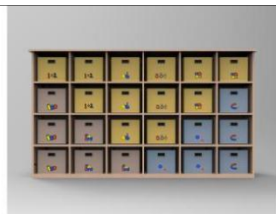
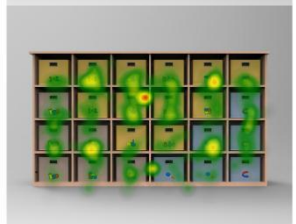
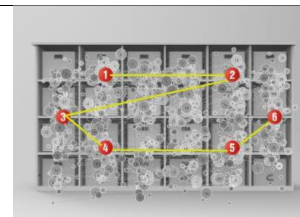
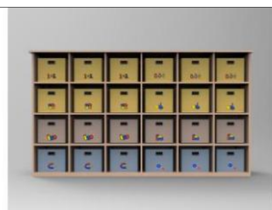
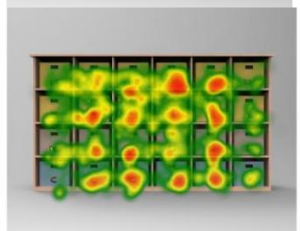
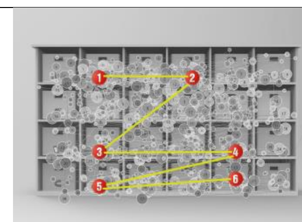
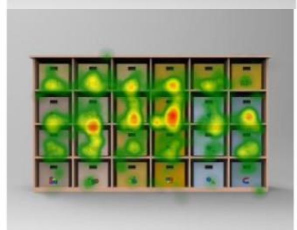
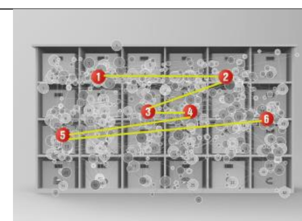
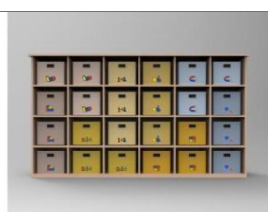
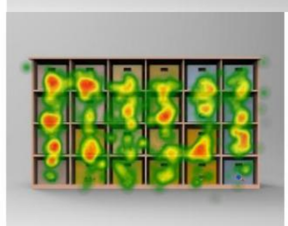
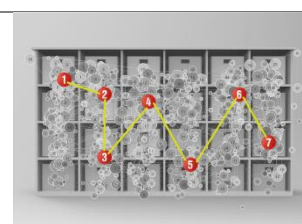
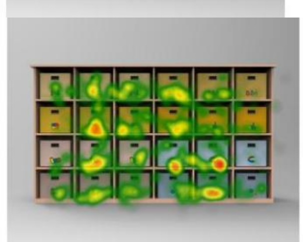
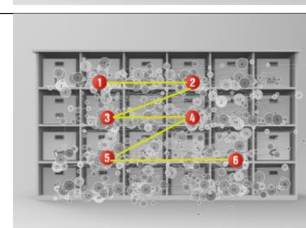
Serial Number	Original Image	Hotspot Map	Track Map
1			
2-4			
2-7			
2-11			
3-6			
3-10			
3-12			

Table 7. Area of the First Viewing Point

Serial number	2-1	2-2	2-3	2-4	2-5	2-6	2-7	2-8	2-9	2-10	2-11	2-12	2-13
First point of view area	P	P	P	P	P	P	P	P	P	C	P	P	S
Serial number	3-1	3-2	3-3	3-4	3-5	3-6	3-7	3-8	3-9	3-10	3-11	3-12	3-13
First point of view area	P	S	P	P	P	P	P	P	P	C	P	P	S

In the table, P represents puzzle area, C represents construction area, and S represents science observation area.

In the second group of 13 scenarios, the shortest average gaze time was for serial number 2-11, followed by serial number 2-13, and then serial number 2-12. The duration was 7.487 s, 7.610 s, and 7.669 s, respectively; the longest average gaze time was for serial number 2-9, followed by serial number 2-4, and then serial number 2-8. The duration was 10.001 s, 9.295 s and 9.211 s, respectively.

Among the 13 scenarios in the third group, the shortest average gaze time was for serial number 3-12, followed by serial number 3-11, and then serial number 3-13. The duration was 6.224 s, 6.232 s, and 6.257 s, respectively; the longest average gaze time was for serial number 3-9, followed by serial number 3-4, and then serial number 3-10. The duration was 8.443 s, 8.282 s and 8.246 s, respectively (Table 8).

Table 8. Average Gaze Time

Serial Number	1	2-1	2-2	2-3	2-4	2-5	2-6
Average gaze time (s)	9.828	8.730	8.962	9.189	9.295	8.783	8.589
Serial number	2-7	2-8	2-9	2-10	2-11	2-12	2-13
Average gaze time (s)	8.762	9.211	10.001	9.192	7.487	7.669	7.610
Serial number	3-1	3-2	3-3	3-4	3-5	3-6	3-7
Average gaze time (s)	8.217	8.120	7.301	8.282	7.326	7.138	7.871
Serial number	3-8	3-9	3-10	3-11	3-12	3-13	
Average gaze time (s)	7.904	8.443	8.246	6.232	6.2244	6.257	

The average gaze time for the first group was 9.828 s, the overall average gaze time for the second group was 8.729 s, and the overall average gaze time for the third group was

7.505 s. It can be seen that the three-color partitioning was better than the colorless partitioning in terms of information extraction efficiency, while adding hues for partitioning was better than the three-color partitioning in terms of information extraction efficiency. Combined with the eye-trajectory diagram, it can be seen that when the subjects observed the third group of locker samples with increased hue, they reduced the unnecessary looking back due to the difference in hue, which effectively reduced the information extraction time.

Optimal layout selection

The data of total gaze time for the three samples with serial numbers 3-11, 3-12, and 3-13 were analyzed in conjunction with SPSS. The results of the chi-square test in Tables 9 and 10 showed that the one-way variance significance level was greater than 0.05, indicating that there was no significant difference in the subjects' total gaze time when observing the above three samples with different layouts.

Table 9. Chi-square Test 1

Chi-square Test					
		Levin Statistics	Degree of Freedom 1	Degree of Freedom 2	Significance
Time	Average based	0.479	2	87	0.621
	Based on median	0.493	2	87	0.613
	Median-based with adjusted degrees of freedom	0.493	2	85.774	0.613
	Based on the mean value after clipping	0.507	2	87	0.604

Table 10. Chi-square Test 2

Multiple Comparisons						
Dependent Variable: Time						
LSD						
(I) Grouping	(J) Grouping	Mean Difference (I-J)	Standard Error	Significance	95% Confidence interval	
					Lower limit	Upper limit
1	2	0.00667	0.66643	0.992	-1.3179	1.3313
	3	0.02599	0.66643	0.969	-1.3506	1.2986
2	1	0.00667	0.66643	0.992	-1.3313	1.3179
	3	0.03267	0.66643	0.961	-1.3573	1.2919
3	1	0.02599	0.66643	0.969	-1.2986	1.3506
	2	0.03267	0.66643	0.961	-1.2919	1.3573

The standard deviation of the total gaze time was calculated for samples 3-11, 3-12, and 3-13 (Table 11). From the table, the standard deviation of sample 3-13 was the lowest among the three samples, indicating that the data of this sample were less discrete than the remaining two samples in terms of total gaze time. Therefore, sample 3-13 was selected as the optimal toy locker layout solution.

Table 11. Standard Deviation of Total Gaze Time

Serial Number	Standard Deviation
3-11	2.563343685
3-12	2.79345411
3-13	2.368650796

DISCUSSION

To make the design objectives clear, AHP hierarchical analysis was used for the determination of each requirement weight, but the method has certain limitations: AHP hierarchical analysis has a strong subjective character in the process of determining the index weight vector, so it affects the results of each requirement weight to some extent.

The eye-movement experiment sample only distinguishes the layout from color and further divides the kindergarten toy locker from hue through color semantics, and subsequent design optimization can be done from the tactile and material texture level of partitioning, and conduct in-depth research on the physical, chemical, mechanical, and technological properties of storage cabinet materials to explore whether the efficiency of storage for young children can be further improved based on the current study.

During the eye-movement experiment, children first gazed at the AOI area mostly in the puzzle area, which was influenced by two main factors in addition to the subjects' eye-movement manipulation habits:

1. The yellow color for the puzzle area is more saturated and brighter than the blue color for the science area and the log color for the construction area, and children's eyes are more likely to be influenced by it and look at it for the first time.

2. The focus point is related to the size of the layout. The layout of the puzzle area accounts for 50% of the overall layout, while the layout of the science area and the construction area each account for 25% of the overall layout. Therefore, the puzzle area is more likely to be watched than the science observation area and construction area.

SUMMARY

This study investigated the storage behavior and needs of special groups in kindergartens, and it was concluded that the difficulty encountered by users in the operation and use of kindergarten toy lockers was that they cannot efficiently store toys. By conducting eye movement experiments related to the layout of kindergarten toy lockers for children aged 3 to 6 and comprehensively analyzing different eye movement data, the layout of toy lockers that is most conducive to children's efficient storage was obtained, so that toy lockers could better guide and cultivate children's classification storage cognition, reduce the error rate of toy classification and partition storage, and carry out systematic development, design and research on kindergarten toy lockers.

This study explored the optimization of the layout of lockers through eye movement experiments. The proper layout of storage partitions has great significance for children: in the game of toy storage, they become more efficient, making them more willing to actively put things in order. Therefore, it can effectively mobilize children's classified storage ability and enthusiasm and cultivate personal life skills and good habits. In addition, a reasonable storage partition layout is also conducive to improving the quality of kindergarten game education facilities and creating a kindergarten play environment and teaching environment conducive to the development of children.

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APPENDIX
Supplementary Information

OBSERVATION STUDY ON INFANT STORAGE BEHAVIOR

Observation Purpose

In order to deeply understand the specific play process of children, the following was considered: the operation details of taking toys and using storage furniture; consideration of whether the operation behavior is convenient and easy to use from the perspective of children's behavior; and analysis of the actual needs of the user in the process of children's storage behavior. In the form of non-participatory situational observation, four children participating in game activities were filmed and recorded in the dark, focusing on recording the whole game process of children "taking toys - playing games - taking back toys", as well as related cooperative communication behaviors.

Observation Preparation

We asked experienced preschool teachers in advance which game activity children were most interested in in daily life. The results showed that they had the highest interest in building blocks and stayed for the longest time. The purpose was to maintain the consistency and duration of the observation experiment. The goal was to follow the principles of natural observation. Using mobile phone stand and mobile phone equipment, the shooting position was fixed at the horizontal line of sight height of 600 mm, and the distance from the observation area was 100 mm. The filming personnel did not participate in guiding the behavior of the observed people, and they avoided verbal communication as much as possible to reduce interference factors. Through video image processing software, children's behavior and movement and path line were collected in 10 seconds.

Observation Behavior Description Analysis

Schedule of kindergarten children

In the daily procedures of the kindergarten, children are present in the kindergarten from 8 AM to 4 PM, and the day's learning and life are completed. The activities included during the period are outdoor exercise, life activities, collective teaching activities, dining, nap, and game activities. It can be found that children's time in the game is divided into two periods, which are divided into collective teaching activities in the morning and independent game activities in the afternoon, and the activity venue is in the classroom. Group teaching activities are usually gamified teaching, which takes place in an open area in the center of the classroom and lasts about 60 minutes. Teachers and children participate in the game activities together, and teachers guide the game content, which usually includes some enlightenment teaching such as music and dance. Independent game activities are for children to play games with their peers independently, teachers do not participate in the game activities, the location is in each corner of the classroom game space, the duration is more than 60 minutes, children can choose the game space, and choose single or cooperative games.

Expression of children's play behavior

Based on the frame-by-frame analysis of video images, the main movements and behaviors of children were extracted, and the summarized behavior flow chart was shown in Fig. 1. The whole game activity of children took about 30 minutes, and its main scope of activity was concentrated in the central area formed by the encircling of the toy locker. The action line was not fixed, and the direction and route of getting things back and forth mainly depended on the children's current game ideas, and the operation of sitting on the ground took most of the time, accompanied by the behavior of squatting and standing up to pick up toys.

Fig. S1. Itineraries of children's play activities

The process of play was accompanied by communicative behaviors. When children had play behaviors, other partners would be attracted and participated in the game activities together, resulting in spectator play, parallel play, joint play, and cooperative play. There were spectators, that is, they watched their peers play the game but did not actively participate in it, which would produce conversation and inquiry behavior; Parallel players, that is, played with the same toys with peers but did not communicate; Co-players, who played together and communicated with each other, but did not share the same rules and goals for the game; Cooperative players, who played together with common rules and goals, discussed and communicated with each other.

In the process of the game, some of the children had the behavior of leaving halfway, because the attention of the children was easily distracted and easy to be attracted by other things. Some of the companions who left would pick up the toys they took out, while some left directly. Finally, the last remaining children picked up all the toys and items. Girls were more willing to pick up than boys.

There were two kinds of storage behaviors in the process of toy sorting and storage, one was conscious storage behavior, children could know the storage location of toys, and orderly storage of toys. The second was unconscious storage behavior, children forgot the original storage location of toys, and then randomly placed them in a storage space, over time, resulting in the situation of toy hybridity storage.