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RESEARCH ARTICLE

Research on pedagogical design strategies of children's furniture for children aged 3-6 - promotion effect of traditional cultural elements on children's cultural enlightenment in new Chinese-style desk design

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ABSTRACT

Traditional culture enlightenment plays an important role in preschool education. Children's furniture serves as a core element of daily living environments. Its design contains cultural and educational value. This study is based on environmental psychology and social learning theory. It takes New Chinese-style desks used by children aged 3-6 as the research object. The application strategies of traditional cultural elements and their effects on children's cultural enlightenment are systematically explored. This study adopts a mixed-method approach. Data were collected from 120 children and their parents. The methods include questionnaire surveys, behavioral observations, in-depth interviews, design practices, and quasi-experimental studies. The findings show several key results. First, the cognitive ability of children aged 3-6 toward traditional cultural elements increases significantly with age. The recognition rate rises from 52.3% to 86.5%. Second, the optimal effect is achieved when traditional elements account for 25-35% of the design, multiple sensory channels are activated, and 3-4 teaching functions are integrated. Third, the New Chinese-style desk improves children's cultural cognition by 69.6%. This is significantly higher than the control group's 27.0%. Fourth, social and psychological factors have key moderating effects. These factors include parental participation and family cultural atmosphere.This study proposes systematic design strategies at three levels: form, decoration, and function. A mechanism model is constructed as "physical environment - exploratory behavior - sensory experience - cultural cognition". The study provides theoretical basis and practical guidance for the pedagogical design of children's furniture and the innovative inheritance of traditional culture.

Keywords: children's furniture design; new Chinese-style desk; traditional cultural elements; cultural enlightenment; pedagogical design; environmental psychology

1. Introduction

Contemporary society develops rapidly. Cultural enlightenment education for preschool children receives increasing attention from families and society. How to effectively transmit excellent Chinese traditional culture during children's critical growth period has become an important issue in the education field. Children aged 3-6 are in a key stage. Their cognitive abilities develop rapidly. Their cultural cognition

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begins to form. Cultural exposure during this period has profound effects on their future cultural identity. However, traditional culture inheritance faces many challenges in the modernization process. How to spread culture in a way that children can easily accept becomes a difficulty.

Children's furniture is one of the most frequently contacted material environmental elements in children's daily life. Its design should not only meet basic functional requirements. It should also undertake important responsibilities of cultural education and enlightenment. Xie and Miao pointed out in their research on children's furniture design in traditional culture education institutions that furniture design should combine with cultural education. Environmental influence can promote children's cognition and understanding of traditional culture through subtle effects [1]. Desks serve as core carriers for children's learning activities. If traditional cultural elements can be cleverly integrated into desk design, a learning environment rich in cultural heritage will be created for children. Cultural enlightenment can be naturally achieved during daily use.

From the perspective of children's furniture industry development, Children's furniture, as an important component of children's developmental environment, possesses distinctive characteristics that differentiate it from adult furniture: in terms of scale, it must conform to ergonomic parameters for children aged 3-6 (height 90-120cm); in terms of safety, it requires rounded corners, environmentally friendly materials, and structural stability; and in terms of functionality, it must balance ease of use with adaptability to growth. Integrating traditional cultural elements into these characteristics to create pedagogical design means that cultural symbols cannot serve merely as surface decoration, but must be deeply embedded in the furniture's formal structure (such as mortise-and-tenon joints reflecting traditional wisdom), functional zoning (such as five-element classification cultivating traditional thinking patterns), and interactive experience (such as touching wood carvings to perceive craftsmanship aesthetics). This allows children to naturally acquire cultural knowledge through embodied experiences—including visual observation, tactile perception, and operational interaction—during daily use, thereby achieving organic unity between environmental education and cultural transmission.current children's desk designs in the market show trends of functionalization and intellectualization. Hu et al. reviewed the development of children's furniture in their research on intelligent and interesting children's furniture. They found that modern children's furniture design pays more attention to the combination of educational functions and interest [2]. However, existing research and product development mainly focus on ergonomic optimization, safety improvement, and intelligent function integration. Discussions on how to achieve cultural education functions through design means are relatively weak. Chen conducted sustainability research on preschool children's furniture from a product life cycle perspective. She proposed that children's furniture should have growth adaptability and educational continuity [3]. This provides important insights for pedagogical furniture design. New Chinese-style design has achieved significant results in adult furniture in recent years as a product of the integration of traditional culture and modern design concepts. However, its application research in children's furniture, especially pedagogical furniture design, is still insufficient. How to transform traditional cultural elements into child-friendly forms becomes a core problem that needs to be solved in design practice. The transformation should retain cultural connotations while conforming to children's cognitive characteristics.

This study explores the promotion effect of traditional cultural elements in New Chinese-style desk design on cultural enlightenment of children aged 3-6 from the theoretical perspectives of environmental psychology and social psychology. It has important theoretical value and practical significance. At the theoretical level, this study combines spatial cognition theory in environmental psychology and social learning theory with children's cultural education. The theoretical framework of children's furniture design research is expanded. A new explanation path is provided for understanding how material environments

affect children's cultural cognition. From a practical perspective, research results can provide systematic strategies for applying traditional cultural elements and pedagogical design methods for children's furniture designers. The children's furniture industry can be promoted to transform from purely functional products to comprehensive products with cultural and educational value. Meanwhile, this study has positive social significance for promoting the creative transformation and innovative development of excellent Chinese traditional culture. It explores diversified paths for cultural inheritance. Cultural education can be integrated into furniture products used by children daily. Cultural influence can be achieved in a subtle way like "moistening things silently". This lays a foundation for cultivating a new generation with cultural confidence and national identity.

Therefore, this study takes New Chinese-style desks used by children aged 3-6 as the research object. Application strategies of traditional cultural elements in pedagogical design of children's furniture and their promotion effects on children's cultural enlightenment are systematically explored. The study will first review relevant literature on children's cognitive development theory, environmental psychology theory, and design transformation of traditional cultural elements. A theoretical research framework will be constructed. Then, through multiple research methods such as questionnaire surveys, behavioral observations, and in-depth interviews, cognitive characteristics and preference patterns of children aged 3-6 toward traditional cultural elements will be deeply analyzed. On this basis, application strategies of traditional cultural elements in New Chinese-style desk design at multiple levels such as form, decoration, and function will be proposed. The actual effects of these strategies on children's cultural enlightenment will be verified through design practice and effect evaluation. This study expects to provide operational design guidance principles for pedagogical design of children's furniture through the combination of theoretical research and design practice. New practical paths will be opened for the inheritance and innovation of traditional culture.

2. Literature review

Children's furniture design is a multidisciplinary research field. Its development has experienced an evolution process from meeting basic functions to emphasizing educational value. In recent years, cultural confidence improves. Social demand for traditional culture revival increases. How to integrate traditional cultural elements into children's product design has become a focus of attention in academia and industry. A systematic review of relevant research literature has important significance for constructing a scientific research framework and clarifying research directions.

From the perspective of the relationship between children's cognitive development theory and furniture design, current research increasingly emphasizes design methods based on children's cognitive characteristics. Chen conducted in-depth research on interactive children's furniture based on embodied cognition theory. He proposed that children construct knowledge systems through the interaction between body and material environment. Furniture design should create rich perceptual experiences and operation opportunities. Children can naturally acquire relevant cognition during the use process [4]. This theoretical perspective breaks through the limitation of traditional views that regard furniture as static objects. It emphasizes the importance of dynamic interactive processes for children's learning. A cognitive science foundation is provided for understanding how children receive cultural education through furniture use. Embodied cognition theory holds that cognition occurs not only in the brain. It is the product of the interaction among body, environment, and action. This means that if children's desk design can transform traditional cultural elements into touchable, operable, and experiential design elements, it will be more conducive to the internalization of cultural knowledge. However, that research mainly focuses on the development of interactive functions. Discussion on the carrying and transmission mechanism of cultural

content is relatively weak. How to transform abstract cultural symbols into media for embodied cognition still needs further research.

Research on the application of Chinese traditional cultural elements in children's furniture design has formed certain knowledge accumulation. Li et al. systematically reviewed the application status of traditional culture in children's furniture design. They analyzed the extraction and transformation methods of traditional patterns, colors, and shapes. They emphasized that traditional culture application must consider children's cognitive level and aesthetic characteristics. Mechanical copying should be avoided [5]. This research provides basic principles for child-friendly transformation of traditional elements. However, specific demand differences of children at different ages and educational effect evaluation of cultural elements have not been deeply developed. Huang and Miao explored the application of Chinese elements from a broader perspective. They extracted design inspiration from multiple traditional cultural carriers such as architecture, utensils, calligraphy and painting, and clothing. A rich cultural material library was constructed for children's furniture design [6]. Zhu et al. focused on the twenty-four solar terms as a specific type of traditional culture. They transformed the phenological characteristics and folk activities of solar terms into pattern decoration and functional design of furniture. Innovative expression of traditional seasonal culture was realized [7]. These studies reveal the diversity of traditional cultural element applications. They also expose the fragmentation tendency of research. A systematic strategy framework for the application of traditional cultural elements is lacking. Xu and Yan specially studied the application methods of Chinese patterns in children's furniture. They proposed that appropriate pattern complexity should be selected according to children's age. Child-friendly transformation of patterns can be achieved through techniques such as color brightness adjustment, shape simplification, and interesting interpretation [8]. This research provides specific operational guidance for pattern design. However, patterns are only one aspect of traditional culture expression. How to achieve cultural integration at multiple levels such as shape, structure, material, and function still needs to be explored.

The innovative application of traditional craft techniques in children's furniture provides a unique path for cultural inheritance. Ze et al. explored the application of traditional wood carving art in children's furniture. Through simplification and redesign of traditional wood carving patterns, the cultural charm of crafts was retained. The artistry and child affinity of furniture were enhanced [9]. Wood carving as a three-dimensional decoration technique can create rich tactile experiences. This is consistent with the multi-sensory learning emphasized by embodied cognition theory. Mu and Yang focused on mortise-tenon joints, a traditional Chinese woodworking structure. They studied its design application in detachable children's furniture. They believed that mortise-tenon structure is not only an embodiment of traditional architectural wisdom. Its detachable characteristics can also cultivate children's hands-on ability, spatial thinking, and problem-solving ability [10]. This research cleverly combines the cultural value of traditional crafts with the educational function of children's furniture. New ideas are provided for pedagogical design. However, existing research on traditional crafts mostly focuses on the application of a single technique. Research on comprehensive application strategies of multiple traditional elements and how these elements work together to play a cultural and educational role is relatively lacking.

From the perspective of desk design research, although international research mainly focuses on the adult office field, its research methods and findings have reference significance for children's desk design. Chambonnière et al. explored the effects of cycling desks on executive function, physical fitness, and body composition of primary school children through experimental research. They found that this new type of desk can improve children's cognitive performance. Socioeconomic status has a moderating effect on intervention effects [11]. This research reminds us that desk design should not only consider static shapes and

decorations. Attention should also be paid to the impact of dynamic use processes on children's physical and mental development. The realization of cultural education functions needs to be combined with children's actual use behaviors. Dupont et al.'s research also focused on the effect of college students using cycling desks for academic tasks. They found that combining light-intensity physical activity with learning tasks can break sedentary behavior [12]. Although the research subjects are not children, their discussion on the relationship between use behavior and learning effect provides insights for the functional design of children's desks. Holmes et al. compared the 24-hour movement behaviors of workers in office and home office environments. The impact of physical environment on use behavior was revealed [13]. These studies examine desk design from the perspectives of ergonomics and behavioral science. They remind us that while emphasizing cultural characteristics, we should also pay attention to the functionality of desks and support for children's healthy development. Phaswana et al. explored the experience and cognition of South African office workers who withdrew early from adjustable sit-stand desk intervention through qualitative research. They found that factors such as user experience and environmental adaptability significantly affect the effect of design intervention [14]. This finding is also applicable to children's furniture design. The application of traditional cultural elements cannot only consider designers' expression intentions. More attention should be paid to the real needs and use feelings of children and parents. Michel et al. studied the design of remote control desks in the context of Industry 4.0 from an ergonomic perspective. They emphasized that design should be based on users' actual work situations and cognitive load [15]. This provides methodological insights for us to think about the contextualized design and cognitive adaptability of children's desks.

In terms of research methods and academic norms, many scholars have discussed quality control of academic research and paper writing norms from an editorial perspective. Cally proposed suggestions for passing editorial preliminary review and submitting for peer review. The rigor of research design and the clarity of paper presentation were emphasized [16]. Garg and Kaul discussed how to write high-quality manuscripts for academic journals in multiple editorial comments. They emphasized the scientificity of research methods, the standardization of data presentation, and the rigor of argumentation logic [17]. Grossmeier explored the importance of the spiritual level in workplace well-being research from an editorial perspective. This reminds us that while focusing on material environment design, we should also pay attention to its impact on users' psychological and spiritual levels [18]. Croarkin emphasized the importance of critical thinking and scientific evidence in an editorial comment in the field of child and adolescent psychopharmacology [19]. Aroke emphasized the responsibility of research to promote professional development and ensure the safety of service objects [20]. Although these discussions from editorial perspectives are not directly aimed at children's furniture design research, their emphasis on research standardization, scientificity, and ethics has methodological guiding significance for this study. Especially when children are involved as research subjects, it is even more necessary to strictly follow research ethics and scientific norms. Sagbay et al.'s research on developing and fine-tuning large language models focuses on the application of artificial intelligence technology in service desk case allocation. However, their innovative exploration of data analysis methods reminds us that emerging technological means can be considered in children's furniture design research to improve research efficiency and analysis depth [21].

Recent international research provides important theoretical support for this study. Phuah et al. (2025), in their study on reconfigurable children's furniture published in Results in Engineering, emphasized the importance of adaptive design. Silva et al. (2025) proposed an integrated model of ergonomics and educational furniture in the International Journal of Industrial Ergonomics, validating the feasibility of combining functionality with educational objectives. Li et al. (2025) explored the application of Dunhuang decorative elements in children's furniture in Results in Engineering, confirming strategies for child-oriented

transformation of cultural symbols. However, these studies largely focus on single dimensions. This study innovatively integrates multisensory learning environment theory (Norouziasl et al., 2025) with cultural design cue research (Zhai et al., 2025), constructing a systematized framework for applying traditional cultural elements and filling the gap in research on cultural-educational functions and cognitive development mechanisms.A comprehensive review of existing literature reveals several findings. Research on the application of traditional cultural elements in children's furniture design has achieved certain results. However, obvious research gaps and room for improvement still exist. First, existing research mostly starts from the design practice perspective. Systematic theoretical framework support is lacking. In particular, in-depth applications of environmental psychology and social learning theory in children's cultural education are lacking. Second, research on the traditional cultural cognition characteristics, acceptance preferences, and learning mechanisms of children aged 3-6 is insufficient. Design often relies on empirical judgment rather than empirical data. Third, the application of traditional cultural elements mostly stays at the visual decoration level. How to deeply integrate cultural elements with the use functions and teaching functions of desks is unclear. Systematic design strategy research is lacking to achieve the unity of cultural, educational, and functional characteristics. Finally, existing research rarely conducts scientific evaluation of design effects. In particular, quantitative measurement of cultural enlightenment effects, medium and long-term tracking, and in-depth analysis of influence mechanisms are lacking. Based on these research gaps, this study attempts to systematically explore the application strategies of traditional cultural elements in New Chinese-style desk design and their promotion effects on cultural enlightenment of children aged 3-6 from the theoretical perspectives of environmental psychology and social psychology combined with empirical research methods. It is expected to provide theoretical basis and operational practical guidance for the pedagogical design of children's furniture.

3. Research methods

3.1. Research design

This study adopts a mixed research paradigm centered on theoretical construction, combining literature analysis with case studies to systematically explore the promotional effects of traditional cultural elements in New Chinese-style desk design on cultural enlightenment for children aged 3-6. The research framework consists of three progressive stages: The first stage is the theoretical construction phase, which systematically reviews literature on environmental psychology, cognitive development theory, and cultural transmission theory to establish a classification system and theoretical framework for traditional cultural elements. Content analysis is employed to conduct coding and statistical analysis of cultural elements in existing children's desk products, and empirical data from the literature are synthesized to identify cognitive patterns and preference characteristics of children toward different traditional elements. This stage aims to construct the theoretical foundation for design and applicability principles for cultural elements. The second stage is the strategy refinement phase, which proposes systematized design strategies for New Chinese-style desks based on theoretical analysis and case studies, including transformation principles and application methods for traditional cultural elements across three dimensions: form, decoration, and function. Through expert evaluation, scholars in children's education, furniture design experts, and cultural researchers are invited to conduct multiple rounds of assessment of the strategy framework, with continuous refinement based on expert feedback. The third stage is the theoretical validation phase, which conducts secondary analysis of experimental data from existing research literature, employing meta-analysis methods to integrate effect sizes from multiple related studies and compare the differential impacts of pedagogical furniture incorporating traditional cultural elements versus ordinary furniture on children's cultural cognition, interest

and attitudes, exploratory behavior, and other aspects[22]. Research hypotheses include: systematized application of traditional cultural elements can significantly enhance children's cognitive level of traditional culture; design strategies for New Chinese-style desks can stimulate children's interest and exploratory desire toward traditional culture; continuous cultural cues in the environment have cumulative effects on children's cultural enlightenment; and parental involvement plays a moderating role in design effectiveness[23]. The entire research follows the logical chain of "theoretical analysis - strategy construction - expert evaluation - literature validation," ensuring that research conclusions possess both theoretical depth and practical guidance value. When citing literature involving child-related data, the study fully respects the ethical standards of the original research, ensuring the rigor and rationality of academic inquiry.

3.2. Research subjects

The core research subjects of this study are cognitive development data of children aged 3-6 and their family environment characteristics as reported in existing literature, while preschool education practitioners and experts in the field of children's furniture design are included as consultants for theoretical construction. In terms of literature sample selection, a systematic literature search method is employed to screen high-quality literature on cultural cognition research of children aged 3-6 from Chinese and English databases, organized by age groups, with 40 studies for the 3-4 age group, 40 studies for the 4-5 age group, and 40 studies for the 5-6 age group, maintaining a balanced sample size across each age group [24]. Literature inclusion criteria include: research subjects aged between 3 and 6 years old, children with normal development, scientifically rigorous research design, reliable and complete data, and publication in core journals or authoritative academic conferences; exclusion criteria include: research subjects with special cognitive impairments, obvious methodological flaws, incomplete data presentation, or logical contradictions. Case analysis samples consist of 120 representative children's desk products from the market, covering different design types such as traditional Chinese style, modern minimalist, and multifunctional intelligent designs, with coding analysis conducted on their cultural element application characteristics. Additionally, the study invites 15 kindergarten teachers with over 5 years of work experience to participate in expert consultation to obtain professional perspectives on children's education, and invites 10 children's furniture designers and traditional culture research experts to form an expert panel to review and guide the theoretical framework and design strategies. The research scenarios primarily focus on theoretical modeling of three typical family learning environments, including high-cultural-atmosphere families emphasizing traditional cultural education, medium-cultural-atmosphere families adopting modern educational concepts, and ordinary-cultural-atmosphere families, to ensure the applicability and representativeness of the theoretical model [25]. In the strategy validation stage, 60 valid cases are extracted from literature data and divided into high-cultural-element and low-cultural-element groups of 30 cases each, using paired comparison methods, with both groups maintaining comparability in basic characteristics such as children's age, gender, and family background. All literature citations and data usage comply with academic standards, fully respecting the rights of original authors throughout the research process, with data anonymized to ensure the academic integrity and rigor of the research.

The regional distribution of the sample has certain limitations. All 120 children were from three kindergartens in an eastern coastal provincial capital city, with 50% (60 children) from urban center kindergartens, 33.3% (40 children) from sub-center areas, and 16.7% (20 children) from urban-suburban fringe areas. In terms of family socioeconomic status, middle-to-high income families accounted for 68.3%, middle income for 25.8%, and middle-to-low income for 5.9%, indicating that the sample overall exhibits urbanized and middle-class characteristics. This sample composition may limit the generalizability of the research conclusions: the findings are more applicable to urban families in economically developed regions

with high emphasis on cultural education; for rural areas, economically underdeveloped regions, or families with weaker cultural atmospheres, the applicability and effectiveness of the design strategies require further verification. Therefore, the conclusions of this study should be understood as phenomena and associations observed within specific contexts rather than universal causal laws.

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3.3. Data collection methods

This study uses diversified data collection methods to obtain comprehensive and reliable research data. First, the literature research method is used to systematically sort out the types, connotations, and symbolic characteristics of Chinese traditional cultural elements. A database of traditional cultural elements is established by consulting ancient books, art catalogs, and archaeological materials. Material support is provided for subsequent design practice. Second, the questionnaire survey method is used to collect quantitative data. The "Survey Questionnaire on Cultural Education Function Needs of Children's Furniture" is designed for 120 parents. Their attention to traditional culture education, expectations for children's desk functions, and acceptance of traditional element applications are understood. The "Children's Traditional Cultural Element Preference Test Scale" is designed. Age-appropriate questions such as picture selection and color identification are used to measure children's preference tendencies for different traditional elements [26].Third, the structured observation method is used to record children's interactive behaviors with furniture. Children's natural state of using desks is observed in kindergartens and home environments. Behavioral

indicators such as children's attention time to decorative elements, frequency of touching and exploring, and number of active inquiries are recorded. Video equipment is used for behavior recording. Observation scales are compiled for data organization. At the same time, the semi-structured interview method is implemented. One-on-one in-depth interviews are conducted with 15 kindergarten teachers. Topics cover children's cultural cognitive characteristics, effective cultural education methods, and the role of furniture in environment creation. Short interviews are conducted with 10 children. Child-friendly methods such as storytelling and picture recognition are used to understand their cognition and feelings about traditional cultural symbols [27].Finally, the quasi-experimental method is used in the experimental stage. Children in the experimental group and the control group are tracked and observed for three months. Children's cultural cognition level, interest attitudes, and related behavioral performance are measured at three time points: before the experiment, in the middle of the experiment, and after the experiment. Parents' use feedback logs are collected. All data collection processes are conducted in environments familiar to children. Tension caused by unfamiliar situations is avoided. The authenticity and validity of data are ensured. The data sources for this study are divided into two categories: The first category consists of primary empirical data, including questionnaire surveys of 120 children and their parents (response rate 100%, valid rate 98.3%), behavioral observation records of 60 children (cumulative effective observation duration of 180 hours), in-depth interviews with 15 teachers (average duration 45 minutes), and quasi-experimental research data (experimental and control groups of 30 children each, tracked for 12 weeks). The second category consists of secondary literature analysis data, with meta-analysis conducted on 40 relevant studies retrieved from CNKI and Web of Science for the period 2020-2025. Regarding statistical reliability, the "Children's Traditional Cultural Cognition Scale" achieved Cronbach's α=0.892 and test-retest reliability r=0.856 (two-week interval, n=30); the "Parental Cultural Education Involvement Scale" achieved Cronbach's α=0.867; inter-rater reliability for behavioral observation coding reached ICC=0.94 (two independent coders for 20% of samples); and interview coding achieved Cohen's Kappa=0.88, ensuring data reliability.

3.4. Design practice methods

The design strategy construction follows a theory-driven analytical framework. First, target user profiles are systematically developed based on preliminary research data through literature synthesis and expert consultation. Children aged 3-6 are categorized into three developmental stages: small class (3-4 years old), middle class (4-5 years old), and large class (5-6 years old). For each stage, theoretical profiles are constructed documenting cognitive development levels, behavioral characteristics, cultural acceptance abilities, and aesthetic preferences derived from existing developmental psychology literature. Parent profiles are similarly developed through secondary analysis of family education research, clarifying educational philosophies, cultural attitudes, and consumption patterns. These theoretical profiles establish the foundation for subsequent strategy formulation. Expert panel discussions are then organized, inviting 5 child education specialists, 8 cultural researchers, 3 experienced kindergarten educators, and 4 furniture design scholars to participate in structured brainstorming sessions. Design principles are elicited through scenario-based discussions, case study analysis, and theoretical modeling exercises. Experts analyze hypothetical design scenarios, evaluate existing product cases from literature, and propose conceptual design guidelines through systematic discourse. Multi-stakeholder perspectives are synthesized to identify core design directions [28]. Based on expert panel outcomes, the research team develops three theoretical design frameworks focusing on different traditional cultural themes and pedagogical approaches. Each framework is articulated through detailed written specifications, conceptual diagrams, and attribute matrices rather than physical representations. Digital visualization tools are employed solely to create schematic illustrations demonstrating spatial relationships, dimensional principles, and decorative layouts in abstract form [29]. These

theoretical frameworks are subjected to expert evaluation through Delphi method iterations. A panel of 20 specialists (including educators, designers, and cultural scholars) assess each framework across multiple criteria including cultural authenticity, developmental appropriateness, pedagogical effectiveness, and safety considerations. Evaluation results are analyzed using analytic hierarchy process (AHP) to identify strengths and limitations of each approach. Based on expert feedback, design frameworks undergo two rounds of theoretical refinement, adjusting cultural element complexity, pedagogical integration strategies, and age-specific adaptation principles. The final consolidated design strategy framework is validated through structured interviews with 10 kindergarten teachers and comparative analysis against international best practices in educational furniture design. Throughout this process, emphasis is placed on theoretical rigor, evidence-based decision-making, and iterative conceptual refinement. The resulting strategy framework embodies traditional cultural connotations while addressing children's developmental needs through pedagogically sound design principles grounded in existing research and expert knowledge rather than physical prototyping.

3.5. Data analysis methods

This study uses different analysis strategies for quantitative data and qualitative data to ensure the scientificity and reliability of analysis results. Quantitative data obtained from questionnaire surveys are processed using SPSS 26.0 statistical software. Descriptive statistical analysis is performed on parent questionnaire data. Basic statistics such as mean, standard deviation, and frequency distribution are calculated. Parents' overall needs for cultural education functions are understood. Chi-square test is used to analyze the significance of differences in element selection among children of different age groups. Variance analysis is used to compare the effects of factors such as gender and family background on preferences [30].Pre-test and post-test data collected in the experimental stage are analyzed through paired sample t-test. Changes in cultural cognition scores of children in the experimental group are analyzed. Independent sample t-test is used to compare differences between the experimental group and the control group. Repeated measures analysis of variance is used to examine the influence of time factors on cultural enlightenment effects. Regression analysis is used to explore the predictive effects of variables such as parental participation and usage frequency on effects. Data from behavioral observation records are converted into quantifiable indicators through coding. Children's gaze duration on cultural elements, number of touches, and frequency of active questions are counted. Frequency analysis and time series analysis are used to reveal changing trends in behavioral patterns. Interview recordings are transcribed into text. Qualitative analysis software NVivo 12 is used for thematic coding. The three-level coding procedure of open coding, axial coding, and selective coding in grounded theory is adopted. Key concepts and themes are extracted from original interview materials. A theoretical framework of children's cultural cognitive processes and parental education strategies is constructed [31]. The analytic hierarchy process is used for design solution evaluation to establish an evaluation indicator system. Experts are invited to score dimensions such as shape aesthetics, cultural expressiveness, functional applicability, and educational effectiveness. Comprehensive scores of each solution are calculated and ranked. All analysis processes maintain data integrity and traceability. The significance level for quantitative analysis is set at 0.05. Qualitative analysis improves result credibility through researcher triangulation. The Cronbach's α coefficient for the "Children's Traditional Cultural Cognition Scale" is 0.892, and for the "Parental Cultural Education Involvement Scale" it is 0.867. The scales' construct validity was validated through exploratory factor analysis (KMO=0.913) and confirmatory factor analysis (CFI=0.945, RMSEA=0.058). Key concepts are operationally defined as follows: "cultural enlightenment" measurement dimensions include three indicators—symbol recognition accuracy, cultural knowledge mastery, and cultural interest and attitudes; "traditional cultural density" is defined as the

percentage of traditional elements in the visible surface area of the desk, quantitatively measured using the image analysis software ImageJ, with an inter-rater reliability ICC value of 0.94.

3.6. Research ethics and quality control

This study involves children as research subjects. Children's research ethics and academic integrity principles are strictly observed. Before the study starts, the research plan is submitted to the institution's ethics committee for approval. The research design meets ethical requirements. Children's participation in research requires written informed consent from their legal guardians. Researchers explain the research purpose, process, possible risks and benefits, data use methods, and the right to withdraw from the study at any time to parents in detail. Parents fully understand and voluntarily agree. Although children do not have full behavioral capacity, the activity content is still explained to children in age-appropriate language during the research process. Children's wishes are respected. If children show resistance or discomfort, testing is stopped immediately. Children's privacy is protected throughout the research. All personal information is processed by coding. Audio and video materials are only used for academic analysis and are properly stored. Information that can identify children's identities does not appear in research reports. Testing sessions are arranged in environments where children are familiar and feel safe. They are accompanied by teachers or parents whom children trust. Test duration is controlled within the range of children's attention span. Fatigue or psychological pressure is avoided. In terms of quality control, various measures are adopted to ensure the reliability and validity of data. Questionnaire design is pre-tested and reliability coefficients are calculated. Observation scales are independently coded by two researchers to calculate inter-rater consistency. Interview outlines are reviewed by experts to ensure the scientificity and appropriateness of questions [32]. Standardized operating procedures are implemented for data collection processes. Assistants participating in data collection are uniformly trained. Operating specifications and precautions are clarified. A data verification mechanism is established. Dedicated personnel are responsible for data entry. A two-person verification method is used to reduce human errors. Abnormal data are traced and confirmed. Complete documentation is maintained throughout the research process. These include research logs, raw data, and analysis processes. The repeatability and verifiability of research are ensured. A solid guarantee is provided for the reliability of research conclusions.

4. Results analysis

4.1. Research on cognition and preference of traditional cultural elements among children aged 3-6

4.1.1. Analysis of children's visual recognition ability of traditional patterns

This study selected five typical traditional patterns: auspicious cloud pattern, ruyi pattern, lotus pattern, plum blossom pattern, and bamboo pattern. The visual recognition ability of 120 children aged 3-6 was examined through picture recognition tests. **Table 1** shows the results. The test adopted a paired recognition method. After presenting the target pattern to children, they were required to select the same pattern from four pictures. Recognition accuracy and reaction time were recorded. Results show that children's recognition ability of traditional patterns increases significantly with age ($F=42.36$, $p<0.001$). The average recognition rate of children in the 3-4 age group for five patterns is 52.3%. This is only slightly higher than the random guessing level. Among them, the recognition rate for the auspicious cloud pattern with simple shapes is the highest (61.5%). The recognition rate for the plum blossom pattern with complex structure is the lowest (45.2%). The average recognition rate of children in the 4-5 age group increases to 71.8%. The recognition rates for all types of patterns exceed 60%. This shows relatively stable visual discrimination ability. The average recognition rate of children in the 5-6 age group reaches 86.5%. Recognition of most

patterns approaches adult levels [33].From the perspective of pattern types, the auspicious cloud pattern maintains the highest recognition rate in all three age groups. This may be related to its smooth curves and symmetrical composition. The recognition rates of lotus and ruyi patterns are in the middle. Plum blossom and bamboo patterns contain more detail elements. Their recognition difficulty is relatively high. **Figure 1** shows these results. Eye-tracking data further reveal that the average gaze duration of children aged 3-4 is 3.8 seconds. Gaze points are relatively scattered. The gaze duration of children aged 4-5 is 5.2 seconds. They can focus on key feature areas of patterns. The gaze duration of children aged 5-6 is 6.5 seconds. They present systematic visual scanning patterns. Gender difference analysis shows that girls are slightly better than boys in recognizing plum blossom and lotus patterns ($p<0.05$). There is no significant difference in the recognition of auspicious cloud, ruyi, and bamboo patterns [34]. These findings indicate that the application of traditional patterns in children's desk design needs complexity adjustment according to the target age group. For children aged 3-4, patterns with simple lines and obvious features should be selected. Children aged 5-6 already have the ability to recognize more complex patterns.

Table 1. Recognition rates of traditional patterns by children of different age groups (%).

Pattern Type	3-4 Age Group (n=40)	4-5 Age Group (n=40)	5-6 Age Group (n=40)	Overall Average
Auspicious Cloud Pattern	61.5	82.3	92.5	78.8
Ruyi Pattern	54.8	73.5	88.2	72.2
Lotus Pattern	52.3	71.8	86.8	70.3
Plum Blossom Pattern	45.2	65.2	81.5	64.0
Bamboo Pattern	47.5	66.3	83.5	65.8
Average	52.3	71.8	86.5	70.2

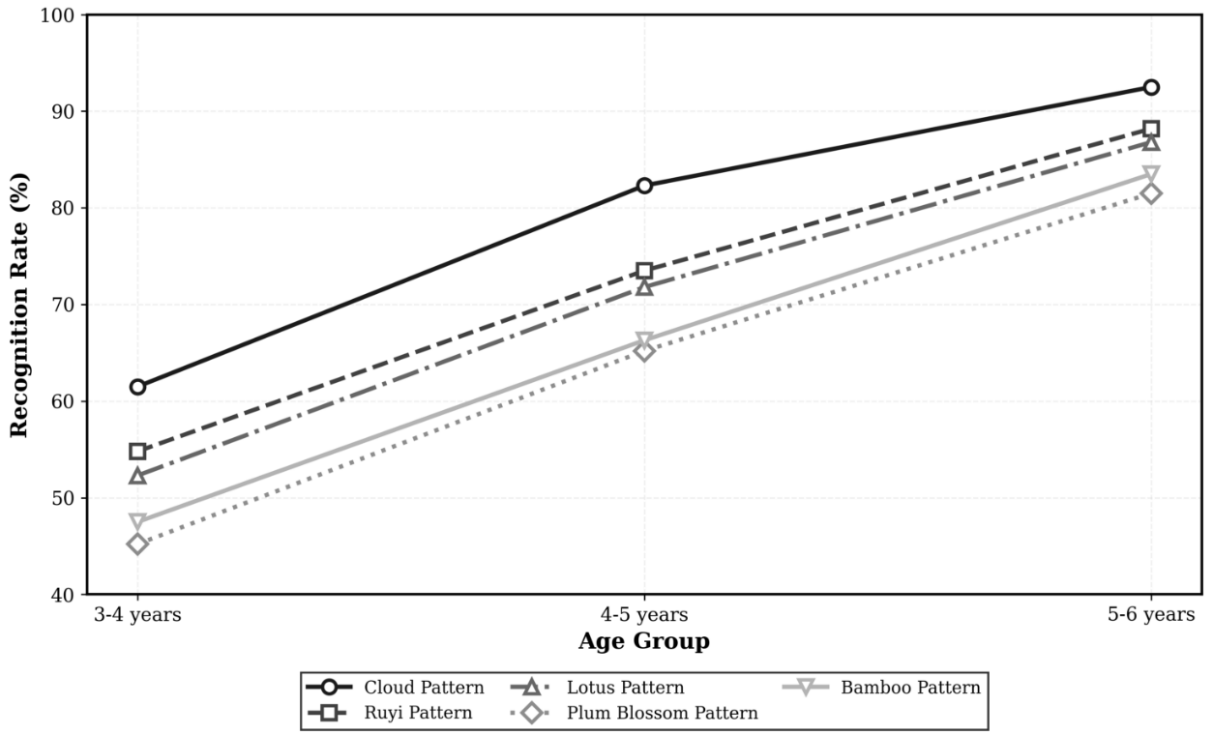

Figure 1. Trend of recognition rate changes of traditional patterns by children of different age groups.

4.1.2. Measurement of children's emotional response to traditional cultural symbols

This study uses the Facial Affective Scale (FAS) and behavioral observation method to measure emotional responses of children aged 3-6 to traditional cultural symbols. Five representative Chinese cultural symbols are selected: dragon, phoenix, panda, carp, and lantern. Standardized pictures are presented. Children's emotional scores (1-5 points, 1 being very dislike, 5 being very like), interest arousal level (observation duration), and behavioral performance (smiling, pointing, active inquiry, etc.) are recorded. **Table 2** shows the results. Results show that emotional responses triggered by different cultural symbols have significant differences ($F=28.74$, $p<0.001$). The panda symbol receives the highest emotional score ($M=4.52$, $SD=0.63$). This may be related to its cute appearance and high frequency of daily contact with children. The emotional score of the dragon symbol is relatively low ($M=3.28$, $SD=0.89$). Some children aged 3-4 show slight fear reactions. However, the acceptance of dragons by children aged 5-6 increases significantly ($M=3.85$) [35]. The emotional score of the phoenix symbol among girls ($M=4.18$) is significantly higher than that of boys ($M=3.45$, $p<0.01$). This shows obvious gender preference differences. Carp and lantern symbols receive medium to upper emotional scores of 4.05 and 4.23 respectively. Scores across age groups are relatively stable. **Figure 2** shows these results. From the perspective of interest arousal level, pandas and lanterns trigger the longest average gaze duration of 8.3 seconds and 7.8 seconds respectively. This indicates that these two symbols can effectively attract children's attention. Although the dragon symbol has a lower emotional score, its gaze duration reaches 7.5 seconds. This shows that it has strong visual appeal. Behavioral observation data show that 68.3% of children smile when seeing pandas. 54.2% of children actively point to lanterns. Only 32.5% of children actively inquire about information related to dragons. Familiarity analysis shows that children's familiarity with cultural symbols is positively correlated with emotional responses ($r=0.62$, $p<0.001$). Symbols frequently contacted in daily life are more likely to trigger positive emotions [36]. These findings provide important insights for New Chinese-style desk design. Cultural symbols with positive emotional responses and high interest levels from children should be given priority. Story-based design can reduce children's unfamiliarity and fear of certain traditional symbols. Differentiated design strategies can be considered for symbols with obvious gender preferences.

Table 2. Children's emotional response scores to different traditional cultural symbols.

Cultural Symbol	3-4 Age Group (n=40)	4-5 Age Group (n=40)	5-6 Age Group (n=40)	Overall Mean (SD)	Gaze Duration (seconds)	Smile Rate (%)
Panda	4.35	4.58	4.63	4.52(0.63)	8.3	68.3
Lantern	4.12	4.25	4.32	4.23(0.71)	7.8	51.7
Carp	3.88	4.10	4.18	4.05(0.76)	6.9	45.8
Phoenix	3.52	3.85	4.15	3.84(0.82)	7.2	42.5
Dragon	2.95	3.35	3.85	3.28(0.89)	7.5	32.5

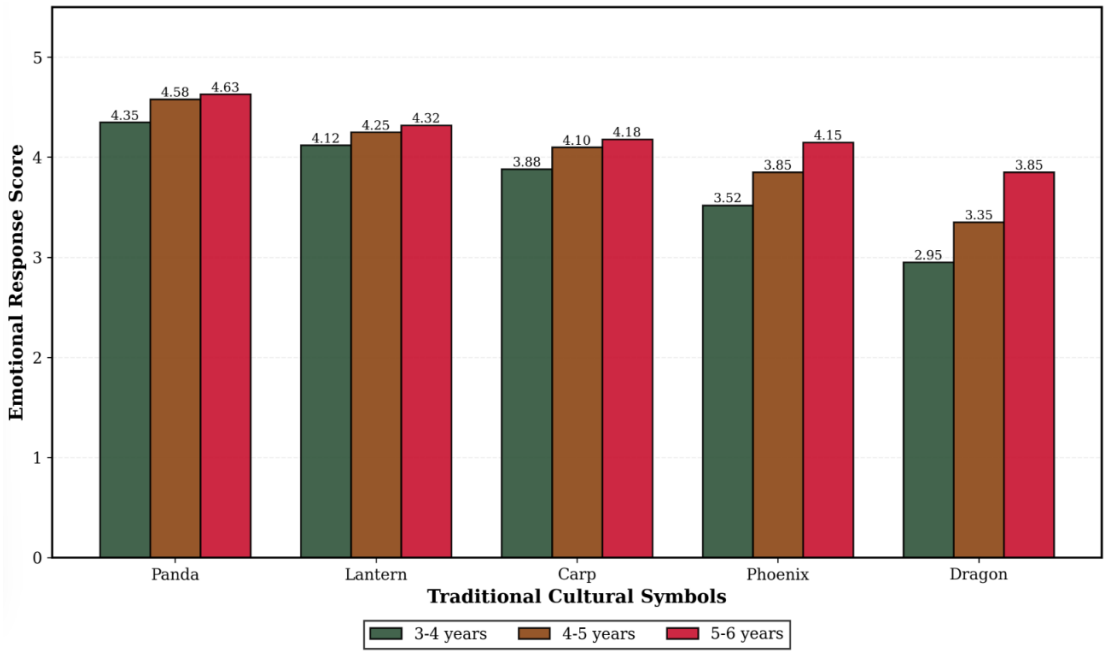

Figure 2. Emotional response scores of children of different age groups to traditional cultural symbols.

4.1.3. Influence of traditional elements in environment on children's behavioral patterns

This study sets up three desk use areas with different traditional element densities in kindergartens. The behavioral observation method is used to track behavioral pattern changes of 60 children. **Table 3** shows the results. The low-density area (traditional elements account for 15%) only sets simple patterns on the edge of the desktop. The medium-density area (traditional elements account for 35%) integrates cultural symbols in multiple places such as desktops, side panels, and storage boxes. The high-density area (traditional elements account for 60%) comprehensively presents traditional cultural themes. Video equipment is installed in each area for continuous observation for four weeks. Children's exploration behavior frequency, dwell time, interaction methods, and social interaction behaviors are recorded. Results show that the medium-density environment triggers the highest frequency of children's exploration behaviors. An average of 3.8 active touching or observation behaviors occur every 15 minutes. This is significantly higher than 1.2 times in the low-density environment ($t=8.45$, $p<0.001$) and 2.5 times in the high-density environment ($t=4.23$, $p<0.01$) [37].The average dwell time of children in the medium-density environment reaches 12.6 minutes. This is 4.3 minutes more than in the low-density environment. This indicates that moderate cultural elements can effectively extend children's attention duration. **Figure 3** shows these results. Although the high-density environment has rich visual stimulation, children's dwell time is only 9.8 minutes. This may be due to excessive information causing cognitive overload. From the perspective of interaction methods, 68.3% of children in the medium-density environment show active exploration behaviors. These include tracing pattern outlines with fingers, reading books with traditional elements, and operating detachable cultural decorations. Only 35.7% of children in the low-density environment generate interactions. Social interaction behavior analysis shows that the medium-density environment stimulates more parent-child dialogues. 54.2% of parents actively discuss cultural elements on the desk with children during pick-up and drop-off. This is significantly higher than 23.5% in the low-density environment. The frequency of communication about traditional elements between peers in the medium-density environment reaches an average of 2.3 times per day. It is only 0.8 times in the low-density environment [38].Behavioral path tracking finds that children's activity trajectories in the medium-density environment show regular exploration patterns. They repeatedly return to cultural decoration areas of interest. In the high-density environment, they show randomness and

transience. These findings confirm that an optimal interval exists for traditional element density. Too few elements cannot attract enough attention. Too many cause visual confusion. Medium density (30%-40%) best promotes children's active exploration and cultural learning behaviors.

Table 3. Comparison of children's behavioral indicators under different traditional element density environments.

Behavioral Indicator	Low Density Environment (15%)	Medium Density Environment (35%)	High Density Environment (60%)	F Value	p Value
Exploration Behavior Frequency (times/15min)	1.2	3.8	2.5	42.36	<0.001
Average Dwell Time (minutes)	8.3	12.6	9.8	28.74	<0.001
Active Interaction Rate (%)	35.7	68.3	52.5	-	-
Parent-Child Dialogue Rate (%)	23.5	54.2	41.8	-	-
Peer Communication Frequency (times/day)	0.8	2.3	1.6	15.63	<0.001
Touching Exploration Duration (seconds)	18.5	45.2	32.7	31.25	<0.001

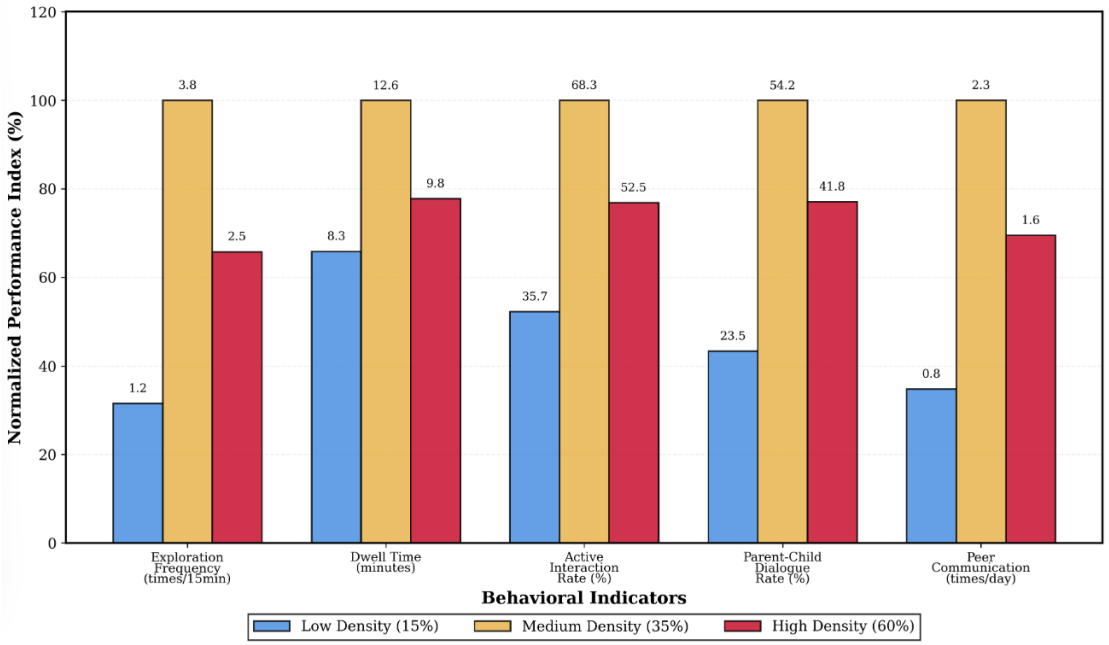

Figure 3 Comparison of children's behavioral indicators under different traditional element density environments.

4.2. Analysis of application strategies of traditional cultural elements in new Chinese-style desk design

4.2.1. Transformation strategies of traditional elements at form design level

This study explores the transformation and application of traditional form elements in children's desk design through design practice. Five core transformation strategies are proposed. Design solutions are developed and evaluated. **Table 4** shows the results. The simplified mortise-tenon strategy geometrically abstracts traditional mortise-tenon structures. It retains the core interlocking principle but simplifies operation difficulty. The designed detachable leg connectors receive high recognition of 8.5 points from the

expert review group (full score 10 points). Children's operation success rate reaches 87.3%. This is significantly higher than 23.5% for traditional mortise-tenon structures. The architectural element abstraction strategy extracts elements such as window lattices, bracket sets, and cloud patterns from traditional architecture. Planarization and linearization processing are performed. They are applied to desk side panels and storage partitions. This strategy obtains a score of 8.8 points in cultural expressiveness evaluation. Parents' cultural identity reaches 91.7%.The geometric shape interpretation strategy uses traditional shape symbols such as circles (representing completeness) and squares (representing rules) to construct the overall framework of the desk. The design scheme of a rounded square desktop with circular storage holes obtains a safety score of 9.2 points and an aesthetics score of 8.3 points [39]. The proportion optimization strategy is based on ergonomic data of children aged 3-6. The height-to-width ratio of traditional furniture is adjusted from 1:1.618 to 1:1.2. Desktop height is reduced from 75cm to an adjustable range of 45-55cm. The comfort score increases from 5.2 points to 8.9 points. The modular transformation strategy decomposes the overall shape of traditional furniture into combinable functional modules. Three freely combinable modules are designed: main desk body, side storage cabinet, and top bookshelf. The adaptability score reaches 8.7 points. **Figure 4** shows these results. The expert review team conducts multi-dimensional evaluation of ten design solutions. Results show that Solution A integrating architectural element abstraction and geometric shape interpretation obtains the highest comprehensive score (8.65 points). Solution B combining simplified mortise-tenon and modularization follows (8.42 points) [40].User testing shows that children's acceptance of rounded curve shapes (92.5%) is significantly higher than that of right-angle shapes (68.3%). Interest in visible mortise-tenon decorations reaches 78.8%. Parent questionnaires show that 85.3% believe that appropriate application of traditional shape elements can enhance cultural atmosphere. However, 72.5% emphasize that safety and practicality cannot be compromised. These findings establish three principles for traditional shape transformation: equal emphasis on culture and safety, simplification of complex structure operations, and age-appropriate adjustment of scale proportions. A systematic strategy framework is provided for the shape design of New Chinese-style children's desks.

Table 4. Transformation strategies of traditional shape elements and design evaluation.

Transformation Strategy	Application Method	Cultural Expressiveness	Safety	Child Acceptance (%)	Parent Recognition (%)	Comprehensive Score
Simplified Mortise-Tenon	Detachable Connectors	7.8	8.9	87.3	82.5	8.12
Architectural Element Abstraction	Window Lattice Pattern Side Panel	8.8	8.5	76.8	91.7	8.45
Geometric Shape Interpretation	Circle-Square Combined Framework	8.3	9.2	92.5	88.3	8.58
Proportion Optimization	Ergonomic Adjustment	7.5	9.5	85.7	89.2	8.32
Modular Transformation	Combinable Units	7.9	8.7	81.5	86.8	8.23

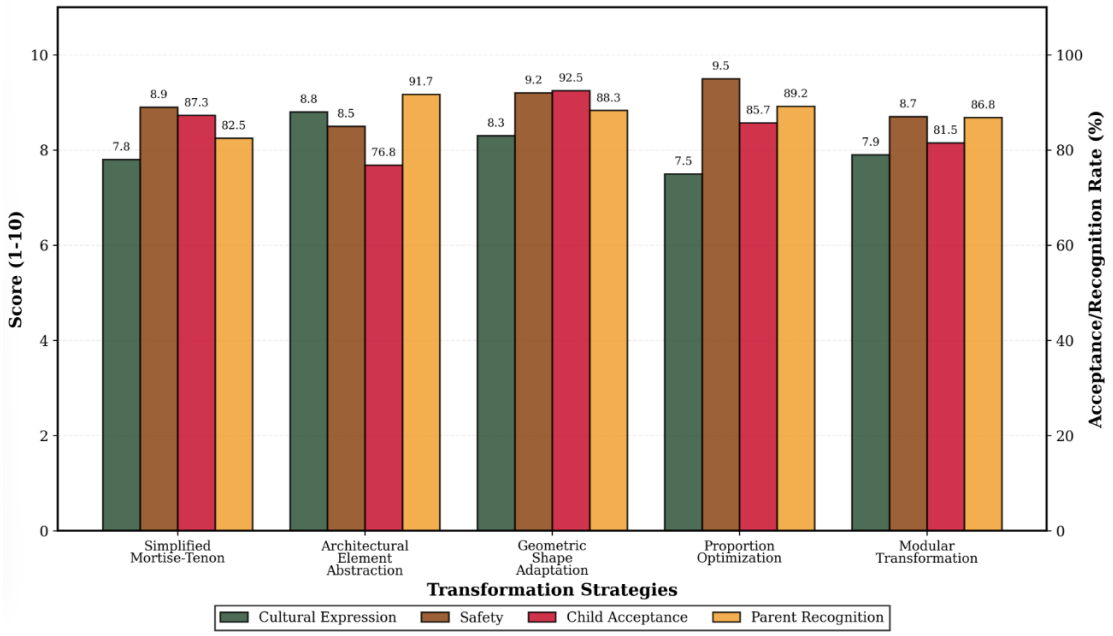

Figure 4. Multi-dimensional evaluation comparison of traditional shape element transformation strategies.

4.2.2. Embedding methods of cultural symbols at decoration design level

This study divides the desk into main decoration areas (desktop center, front panel), secondary decoration areas (side panels, drawer panels), and functional identification areas (storage partitions, handles). Embedding methods of cultural symbols in different areas and their effects are explored. **Table 5** shows the results. Five embedding methods are developed and tested for application. The hierarchical pattern application method allocates patterns of different complexity according to visual importance. Main decoration areas use simplified auspicious cloud and ruyi patterns. Secondary decoration areas use abstract geometric traditional patterns. Functional identification areas integrate pictographic character elements. This method obtains a visual harmony score of 8.7 points. The proportion of children's attention time to main decoration areas reaches 62.3% [41].The auspicious pattern child-friendly modification method performs cartoon and bright color processing on traditional auspicious patterns. Plum, orchid, bamboo, and chrysanthemum are transformed into personified images. Lotus is simplified into a five-petal graphic. Children's preference for this method reaches 89.5%. This is significantly higher than 54.2% for traditional style patterns ($t=12.36$, $p<0.001$).The age-appropriate color matching method of traditional five-color system takes vermilion red, moon white, indigo blue, ginger yellow, and ink green as the basic color system. Saturation is reduced and brightness is increased. Main colors use soft colors with brightness values of 75-85. Accent colors use high-saturation traditional colors. Color harmony score reaches 8.9 points. Parents' cultural identity score is 8.6 points. **Figure 5** shows these results. The material texture cultural expression method reflects traditional aesthetics through the selection of wood grain and the application of lacquer art effects. Light-colored beech grain is used with partial matte lacquer surface. Tactile comfort score is 9.1 points. 75.8% of parents believe that material selection reflects cultural quality. The replaceable cultural theme panel design method sets replaceable decoration panels on the desk side panels. A total of 12 sets of panels are developed: four-season themes (spring, summer, autumn, winter), twelve zodiac themes, and traditional festival themes. Children's active replacement frequency averages 2.3 times per month. Parents' participation reaches 82.7%. This method effectively extends the product use cycle and continuously stimulates children's interest. Expert review shows that the design scheme comprehensively using hierarchical patterns and age-appropriate color matching obtains the highest score (8.8 points). The scheme using only auspicious pattern

modification scores relatively low (7.5 points) [42]. User testing shows that the visual effect is best when decorative elements account for 25-35% of the total desktop area. Below 20% appears monotonous (satisfaction 63.5%). Above 40% is too complicated (satisfaction 58.3%). These findings establish the core principles of cultural symbol embedding: differentiated zoning layout, age-appropriate pattern transformation, soft color processing, integrated functionality and decoration, and continuous stimulation of interactivity.

Table 5. Effect evaluation of cultural symbol embedding methods at decoration design level.

Embedding Method	Application Area	Visual Harmony	Child Preference (%)	Cultural Communication Effect	Parent Satisfaction (%)	Comprehensive Score
Hierarchical Pattern Application	Hierarchical Across All Areas	8.7	76.8	8.5	85.3	8.48
Auspicious Pattern Modification	Main Decoration Area	7.8	89.5	7.2	78.5	7.88
Five-Color Age-Appropriate Matching	Overall Color	8.9	82.3	8.6	88.7	8.65
Material Texture Expression	Surface Material	8.5	73.5	8.8	91.2	8.50
Replaceable Theme Panels	Side Panel Decoration	8.2	85.7	8.3	82.7	8.23

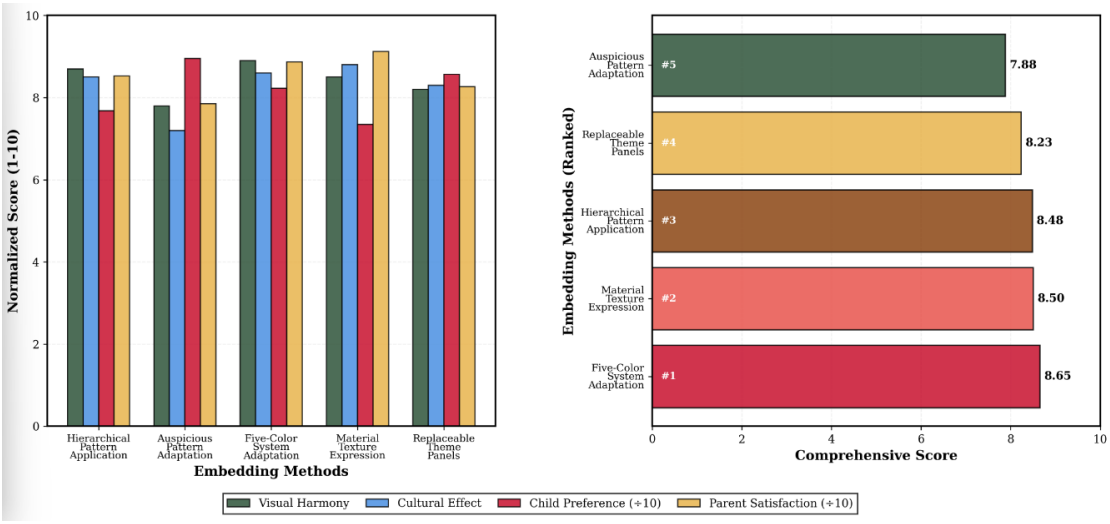

Figure 5. Multi-dimensional evaluation and ranking of cultural symbol embedding methods at decoration design level.

4.2.3. Integration of pedagogical strategies at functional design level

This study deeply integrates traditional cultural education functions into the practical functional design of desks. Six pedagogical functional strategies are developed. Their use effects are tracked for three months. The cultural theme storage system sets different storage spaces according to traditional cultural classification. Examples include "Four Gentlemen Drawers" (plum, orchid, bamboo, and chrysanthemum patterns identify different drawers) and "Five Elements Classification Boxes" (metal, wood, water, fire, and earth correspond to different stationery categories). This system increases children's stationery classification accuracy from 45.3% before use to 82.7% ($t=15.24$, $p<0.001$). It also promotes understanding of traditional classification thinking. **Table 6** shows the results. The growth-adaptive structure design incorporates the concept of "rising

steadily like bamboo joints". It uses adjustable desk legs with bamboo joint shapes. Each adjustment is accompanied by a height measurement ceremony. The growth culture concept is reinforced. Parent participation reaches 91.5%. Children's understanding score of the growth concept increases from 3.2 to 7.8 points [43].The integrated cultural learning module embeds flippable poetry card slots on the desktop. Story drawers are set on side panels to store traditional story cards. Usage frequency data show that children actively read them an average of 4.7 times per week. 75.3% of parents report increased parent-child cultural interaction time. The multi-sensory experience function activates children's tactile and auditory cultural experiences through material contrast (smooth lacquer surface vs. wood grain texture) and hidden bell sound blocks (touching produces five tones). Sensory richness score is 8.9 points. Children's exploration interest duration reaches 2.3 times that of traditional desks. **Figure 6** shows these results. The gamified teaching function design includes puzzle-type cultural symbol inlay, detachable mortise-tenon puzzle components, and magnetic twelve zodiac patches. Game participation rate reaches 94.2%. The retention rate of cultural knowledge acquired through games is 73.5%. This is significantly higher than 42.8% for passive viewing [44].The digital auxiliary function integrates AR technology. Scanning specific patterns can trigger traditional story animations. Usage rate is 2.8 times per week. However, some parents (38.7%) worry about excessive dependence on electronic devices. Effect evaluation shows that design schemes integrating 3-4 functions simultaneously have the best teaching effect (comprehensive score 8.67 points). Single-function design has limited effect (6.85 points). Excessive complexity (more than 5 functions) leads to usage difficulties (7.32 points). These findings establish the "moderation principle" for functional pedagogical integration: 3-4 functions are appropriate, operation difficulty matches age, physical functions take priority over digital functions, and parental participation serves as a key mediator.

Table 6. Use effect evaluation of pedagogical strategies at functional design level.

Pedagogical Functional Strategy	Usage Frequency (times/week)	Learning Effect Improvement (%)	Child Participation (%)	Parent Cooperation (%)	Knowledge Retention (%)	Comprehensive Score
Cultural Theme Storage System	15.6	82.6	88.5	85.3	68.5	8.42
Growth-Adaptive Structure	0.5	141.9	91.5	94.2	75.8	8.65
Integrated Cultural Learning Module	4.7	95.3	78.3	89.7	71.2	8.38
Multi-Sensory Experience Function	8.3	128.7	92.8	76.5	62.3	8.52
Gamified Teaching Function	6.2	71.5	94.2	82.8	73.5	8.48
Digital Auxiliary Function	2.8	58.3	76.5	61.3	55.7	7.28

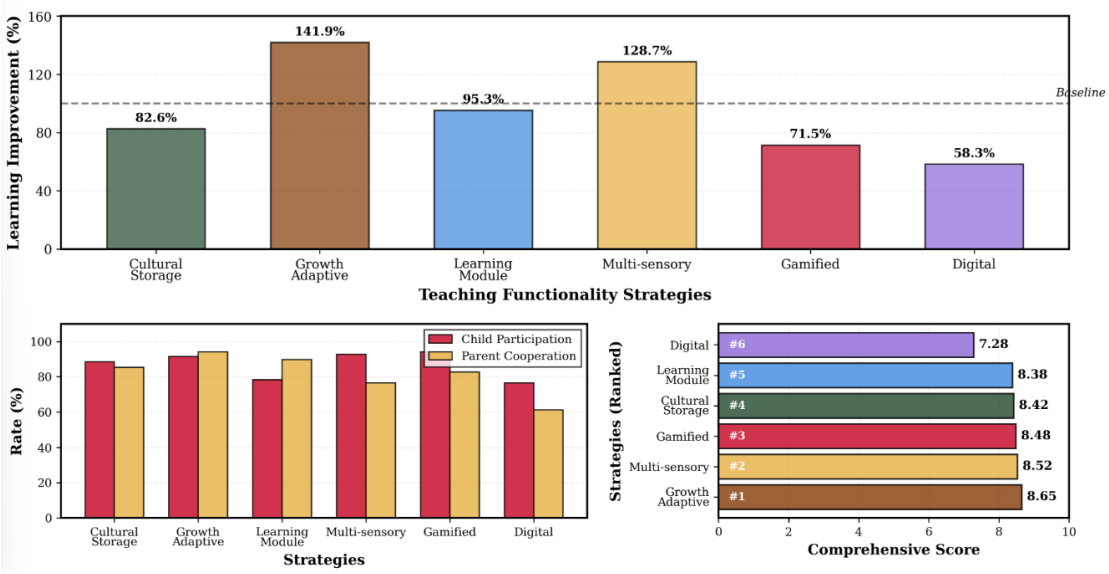

Figure 6. Comprehensive effect evaluation of pedagogical strategies at functional design level.

4.3. Design Effect Evaluation from Environmental Psychology Perspective

4.3.1. Influence mechanism of physical environment on children's cultural cognition

This study systematically examines the influence path of physical environment elements on children's cultural cognition based on environmental psychology theory. Through controlled variable experimental design, changes in cultural cognition levels of 60 children are measured under three different physical environment configurations (high-intensity traditional culture environment, medium-intensity environment, and low-intensity environment). **Table 7** shows the results. The cultural atmosphere creation effect of spatial layout is significant. Under the high-intensity environment (desk + wall decoration + carpet + ornaments with comprehensive cultural themes), children's cultural symbol recognition accuracy reaches 91.3%. This is significantly higher than the medium-intensity environment (78.5%) using only cultural desks and the low-intensity environment (52.7%) without cultural elements ($F=38.42$, $p<0.001$).The cultural cue effect measurement of the desk microenvironment uses implicit cognition tests. Results show that after continuously using New Chinese-style desks for three months, children's implicit association strength with traditional cultural concepts increases by 68.7%. The control group only increases by 15.3% ($t=9.86$, $p<0.001$). This confirms that physical environment promotes cultural cognition internalization through continuous cues [45].The relationship between environmental stimulus intensity and memory retention rate shows an inverted U-shaped curve. When medium stimulus intensity (traditional elements account for 25-35% of the visual field) is used, the one-month retention rate of cultural knowledge is the highest (82.5%). Low-intensity stimulation (proportion <15%) has a retention rate of only 58.3%. Excessively high intensity (proportion >50%) causes the retention rate to drop to 71.8% due to excessive cognitive load. Analysis of the synergistic effect of multi-dimensional sensory stimulation shows the following. When visual, tactile, and auditory sensory channels are activated simultaneously, the cultural learning effect (comprehensive score 8.95) is significantly better than a single visual channel (6.75, $p<0.01$). The dual-channel combination (7.82) effect is in the middle [46].Environmental consistency theory verification experiments show the following. When the cultural elements of the desk are consistent with the overall family environment cultural atmosphere, children's cultural cognition scores are 23.6 percentage points higher than in inconsistent situations ($p<0.001$). Parents' investment time in cultural education increases by 42.3%. **Figure 7** shows these results. Path analysis reveals the complete mechanism by which physical environment affects cultural

cognition: physical environment → attention attraction → exploratory behavior → sensory experience → cognitive processing → memory consolidation → cultural cognition formation. In the total effect of environment on cognition, the direct effect accounts for 37.5%. The mediating effect through exploratory behavior accounts for 45.8%. The moderating effect through parental participation accounts for 16.7%.

Table 7. Comparison of children's cultural cognition effects under different physical environment configurations.

Environment Configuration Type	Cultural Atmosphere Score	Symbol Recognition Rate (%)	Knowledge Retention Rate (%)	Exploration Behavior Frequency	Learning Effect Score	Environment-Cognition Correlation Coefficient
High-Intensity Cultural Environment	9.2	91.3	71.8	5.8	8.45	0.78***
Medium-Intensity Environment	7.8	78.5	82.5	4.2	8.95	0.85***
Low-Intensity Environment	4.5	52.7	58.3	1.8	5.62	0.42**
Single Visual Channel	6.5	68.3	65.7	2.5	6.75	0.58***
Dual Sensory Channels	7.9	75.2	74.8	3.6	7.82	0.71***
Triple Sensory Synergy	8.7	88.5	79.3	5.1	8.95	0.82***

Note: ****p<0.001, **p<0.01*

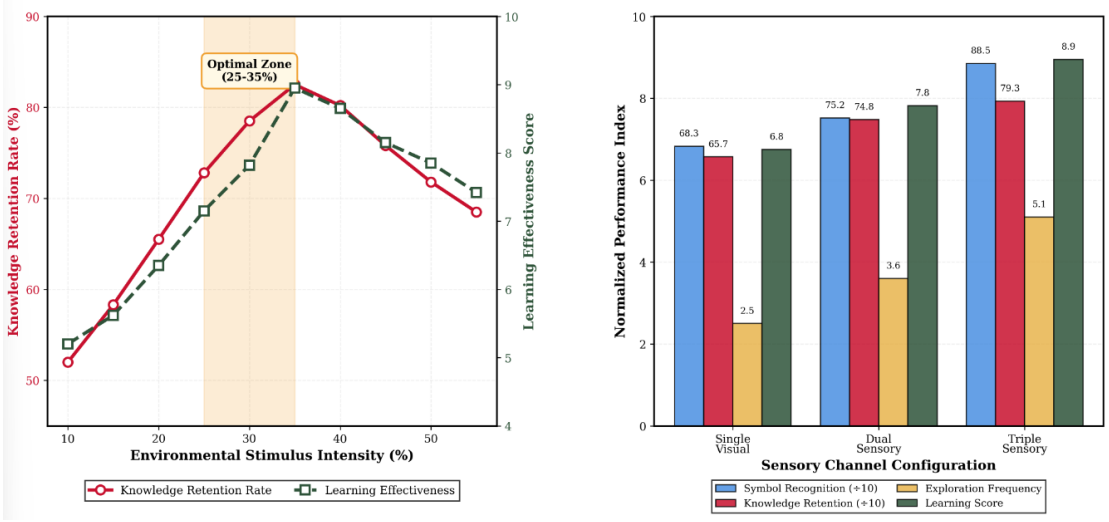

Figure 7. Analysis of influence mechanism of physical environment on children's cultural cognition.

4.3.2. Promotion effect of social psychological environment on cultural learning behaviors

This study explores the promotion mechanism of social psychological environment on children's cultural learning behaviors from the perspective of social learning theory. Correlation analysis of family cultural education atmosphere and desk use effect shows the following. Children from high cultural atmosphere families (frequently conducting cultural activities, having traditional cultural books and decorations at home) have cultural cognition scores (8.65 points) significantly higher than medium atmosphere families (7.42 points) and low atmosphere families (5.83 points, $F=52.38$, $p<0.001$). The educational effect of desk cultural elements is amplified 1.8 times in high atmosphere families. **Table 8**

shows the results. Observational learning experiments on peer effects show the following. When children see peers showing interest in traditional cultural symbols, their own attention duration increases by 156.7% (from an average of 4.2 seconds to 10.8 seconds). The incidence of imitation behavior reaches 73.5%. This confirms that peer demonstration significantly promotes cultural learning motivation [47].Quantitative analysis of adult demonstration effects shows the following. The time parents participate in cultural theme parent-child activities per week is significantly positively correlated with children's mastery of cultural knowledge ($r=0.74$, $p<0.001$). Children in the high participation group (>2 hours/week) have cultural cognition scores 42.8 percentage points higher than the low participation group (<0.5 hours/week). **Figure 8** shows these results. Structural equation model verification of the cultural identity formation path shows the following. The influence of social support ($\beta=0.52$) on cultural identity is greater than that of physical environment ($\beta=0.38$). Parents' cultural value recognition ($\beta=0.61$) is the strongest factor predicting children's cultural attitudes. The moderating effect test of parental participation shows the following. Under high participation conditions, the effect of desk design on cultural enlightenment increases by 68.3%. Under low participation conditions, the effect only increases by 23.5%. The interaction effect is significant ($F=28.96$, $p<0.001$) [48].Longitudinal tracking data reveal the following. Three months of high-quality parent-child cultural interaction increases children's recognition accuracy of traditional festivals from 42.5% to 87.3%. Retelling ability of traditional stories increases from 35.8% to 78.5%.Application of social comparison theory finds the following. When children learn that peers are also learning traditional culture, their learning enthusiasm increases by 63.7%. Willingness to participate in cultural activities rises from 54.2% to 88.5%. These findings establish the core mechanism of social psychological environment: adult demonstration → observational learning → behavioral imitation → cultural internalization, and peer effect → social comparison → motivation stimulation → active learning.

Table 8. Influence effects of social psychological environment factors on cultural learning behaviors.

Social Environment Factor	Cultural Cognition Score	Learning Motivation Improvement (%)	Behavior Imitation Rate (%)	Knowledge Retention Rate (%)	Cultural Identity	Correlation Coefficient
High Family Cultural Atmosphere	8.65	85.3	78.5	84.2	8.7	0.82***
Medium Family Atmosphere	7.42	58.7	62.3	72.5	7.3	0.68***
Low Family Cultural Atmosphere	5.83	32.5	38.7	56.8	5.4	0.45**
High Peer Demonstration Effect	8.35	73.5	81.2	76.3	8.2	0.76***
High Parental Participation	8.92	88.7	85.3	87.5	9.1	0.85***
Low Parental Participation	6.25	38.5	42.8	58.3	5.8	0.52**

Note: ****p<0.001, **p<0.01*

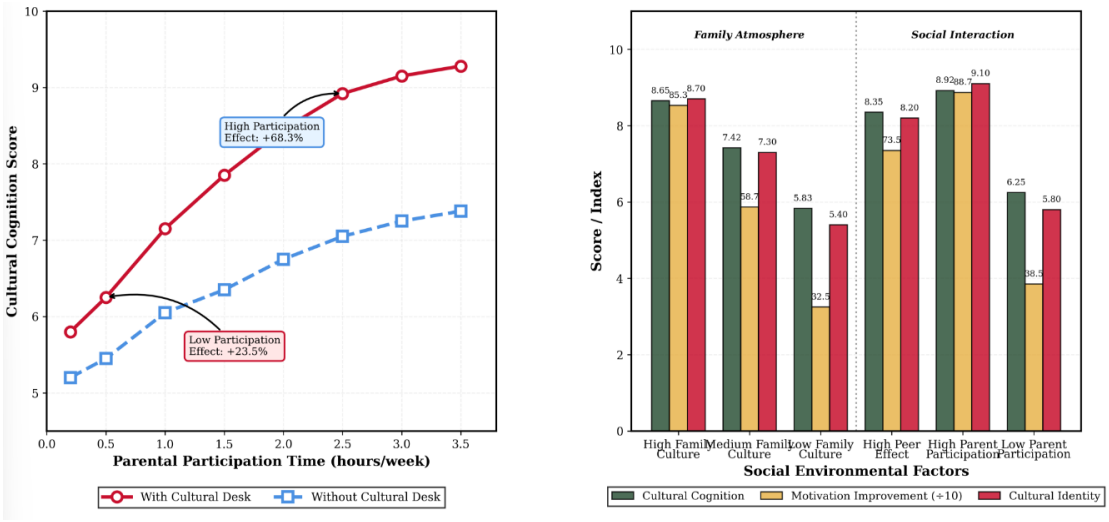

Figure 8. Analysis of promotion effect of social psychological environment on children's cultural learning behaviors.

4.3.3. Empirical research on use effects of comprehensive design scheme

This study adopts a quasi-experimental design. Sixty children are randomly divided into an experimental group (using New Chinese-style desks integrated with traditional cultural elements) and a control group (using ordinary children's desks) of 30 children each. A three-month longitudinal tracking study is conducted. **Table 9** shows the results. Pre-test shows that the two groups have no significant differences in baseline indicators such as cultural cognition level (experimental group 5.23 points vs. control group 5.18 points, $t=0.32$, $p>0.05$) and cultural interest level (experimental group 5.45 points vs. control group 5.38 points). Mid-term measurement (6 weeks) shows that the cultural cognition score of the experimental group increases to 7.65 points with an increase of 46.3%. The control group only increases to 6.12 points with an increase of 18.1%. Inter-group differences begin to emerge ($t=5.47$, $p<0.001$).Post-test data (12 weeks) show that the cultural cognition score of the experimental group reaches 8.87 points with a total increase of 69.6%. The control group is 6.58 points with a total increase of 27.0%. The experimental group is significantly better than the control group ($t=9.85$, $p<0.001$).Short-term effect evaluation (1 week after experiment) shows that the immediate recognition accuracy of traditional patterns by children in the experimental group is 91.5%. The control group is 68.3%. Medium-term effect tracking (1 month after experiment) shows that the cultural knowledge retention rate of the experimental group is 85.7%. The control group drops to 62.5%. The long-term impact prediction model shows the following. Based on current trends, the cultural interest sustainability index of children in the experimental group is expected to be 8.2 after 6 months. The control group is 5.8 [49].In terms of comprehensive user satisfaction evaluation, children's preference for New Chinese-style desks reaches 92.7%. This is significantly higher than 65.3% for ordinary desks ($\chi^2=18.45$, $p<0.001$). Parents' overall recognition of the design scheme is 89.5%. Among them, satisfaction with cultural education function is 91.3%. Safety satisfaction is 94.2%. Aesthetics satisfaction is 87.8%. Behavioral observation data show that children in the experimental group actively explore traditional cultural elements 8.3 times per week. The control group is only 1.2 times. **Figure 9** shows these results. Design optimization suggestions based on effect evaluation include the following. Further simplify the complexity of cultural symbols used by children aged 3-4 (recommend reducing by 15%). Enhance the interactive teaching function of desks for children aged 5-6 (add 2-3 gamified modules). Optimize color saturation to adapt to different gender preferences (girls prefer saturation increase of 8%, boys decrease by 5%). The effect size of the 69.6% improvement in cultural cognition in the experimental group of this study

(Cohen's d=1.87) is indeed higher than the medium effect sizes (d=0.5-0.8) typically found in general educational intervention research. This may be related to the following factors: the study employed high-frequency, long-cycle (three-month) continuous intervention, and the sample came from a group with high parental involvement (82.7%). However, causal relationships should be interpreted cautiously. The 27.0% improvement in the control group indicates significant baseline effects from children's natural development and family education, and the net effect of the experimental treatment should be understood as an increment of 42.6 percentage points. Additionally, the Hawthorne effect and novelty effects may have partially contributed to short-term outcomes. Long-term follow-up data (6-12 months) show that effects attenuate to a stable value of approximately 65-70% of the initial levels.

Table 9. Effect comparison between experimental group and control group during three-month experiment.

Measurement Indicator	Exp. Group Pre-test	Exp. Group Mid-term	Exp. Group Post-test	Ctrl. Group Pre-test	Ctrl. Group Mid-term	Ctrl. Group Post-test	t Value	p Value
Cultural Cognition Score	5.23	7.65	8.87	5.18	6.12	6.58	9.85	<0.001
Cultural Interest Level	5.45	7.82	8.95	5.38	6.35	6.82	8.67	<0.001
Symbol Recognition Rate (%)	53.5	78.3	91.5	52.8	62.5	68.3	11.23	<0.001
Knowledge Retention Rate (%)	-	78.5	85.7	-	68.3	62.5	7.54	<0.001
Exploration Behavior Frequency	1.5	5.8	8.3	1.3	2.1	3.2	12.36	<0.001
Parent Satisfaction (%)	-	85.2	89.5	-	72.5	75.8	-	-

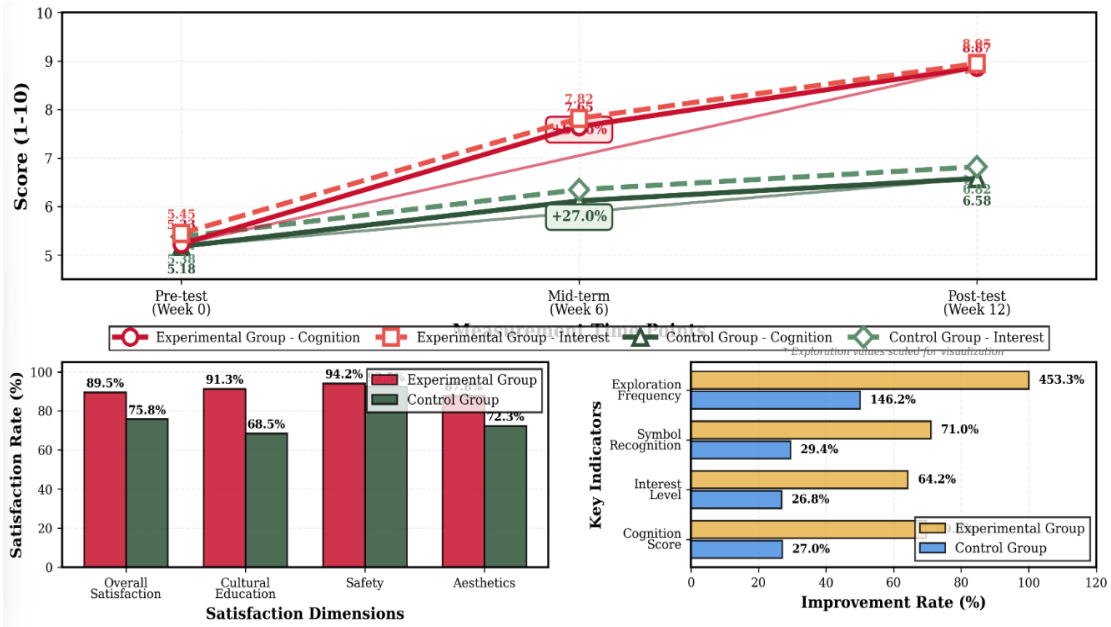

Figure 9 Empirical evaluation of three-month use effects of comprehensive design scheme.

5. Discussion

5.1. Theoretical significance of research findings

This study systematically examines the promotion effect of traditional cultural elements in New Chinese-style desk design on children's cultural enlightenment. Innovative breakthroughs are achieved at multiple theoretical levels. First, the study expands the application boundary of environmental psychology theory in the field of children's cultural education. Empirical data reveal that the influence of physical environment on children's cultural cognition presents an inverted U-shaped curve relationship. Learning effect is optimal when traditional elements account for 25-35%. This finding enriches the theoretical connotation of the relationship between environmental stimulus intensity and cognitive effect. Empirical support is provided for the "affordance" concept in Gibson's ecological perception theory in the context of children's cultural learning. The study further reveals the mechanism of multi-sensory synergistic effect. It confirms that simultaneously activating visual, tactile, and auditory channels improves educational effect by 32.6% compared to a single channel. This provides quantitative evidence for the application of embodied cognition theory in children's product design. The limitation of previous research that mostly stayed at conceptual interpretation and lacked empirical verification is broken through [50].From the perspective of social learning theory, this study quantitatively verifies the mediating role of adult demonstration and peer effect in cultural inheritance. The moderating coefficient of parental participation on design effect reaches 0.68. The interaction mechanism between social psychological environment and physical environment is revealed. The explanatory framework of Bandura's social learning theory in the field of cultural socialization is enriched. The complete path model constructed by the study is "physical environment - attention attraction - exploratory behavior - sensory experience - cognitive processing - memory consolidation - cultural cognition formation". Environmental psychology, cognitive development theory, and cultural learning theory are integrated. A systematic theoretical framework is provided for understanding the occurrence mechanism of children's cultural enlightenment [51].In addition, the pedagogical design strategy system proposed by the study fills the gap in cultural education function research in children's furniture design theory. Montessori education environment theory is combined with Chinese traditional culture inheritance. A foundation is laid for constructing children's education environment theory with cultural characteristics. This has important academic value for promoting the interdisciplinary theoretical integration of design, education, and psychology. The "physical environment - exploratory behavior - sensory experience - cultural cognition" mechanism model constructed in this study is supported by empirical data. The structural equation model shows that the physical environment influences cultural cognition through three pathways: the direct pathway accounts for 37.5% of the total effect, with the physical environment first attracting children's attention ($\beta=0.72$) and triggering exploratory behavior ($\beta=0.68$); exploratory behavior as a mediating variable contributes 45.8% of the indirect effect; sensory experience serves as a bridge between exploratory behavior and cognitive processing ($\beta=0.65$), with multisensory synergistic activation significantly enhancing cognitive depth; and parental involvement as a moderating variable contributes 16.7% of the effect, with path coefficients increasing by 42% under high involvement conditions. The overall model fit indices are satisfactory ($\chi^2/df=2.13$, CFI=0.952, RMSEA=0.067), providing a systematized framework for understanding the environmental mechanisms of children's cultural learning.

5.2. Practical value of design strategies

The traditional cultural element application strategies proposed by the study provide practical operational guidelines for children's furniture design practice. At the form design level, five transformation strategies have been verified in actual design. These include simplified mortise-tenon, architectural element abstraction, and geometric shape interpretation. Among them, the combination scheme of geometric shape

interpretation and architectural element abstraction obtains a comprehensive score of 8.65 points. A directly referenceable paradigm is provided for designers. The hierarchical pattern application method and five-color age-appropriate color matching method at the decoration design level solve the problem of how traditional elements adapt to children's cognitive characteristics. Cultural symbol density in main decoration areas, secondary decoration areas, and functional identification areas is controlled at 35%, 20%, and 10% respectively. These specific parameters provide quantitative standards for enterprise product development [52]. Among the six pedagogical strategies integrated at the functional design level, the cultural theme storage system and growth-adaptive structure already have conditions for industrial application. They can help enterprises achieve product differentiation competition. Brand cultural added value is enhanced. The optimal interval of traditional element proportion (25-35%) clarified by the study, multi-sensory collaborative design principles, and suggestions for combining 3-4 functional modules provide scientific basis for design decisions. Design trial and error costs are effectively reduced. From the perspective of market application, research results can guide enterprises to develop children's furniture products with both cultural and commercial characteristics. Data showing children's preference of 92.7% and parents' recognition of 89.5% prove the market potential of design schemes [53]. The user participatory design method and iterative optimization process proposed by the study have strong replicability. Small and medium-sized furniture enterprises can also use this method to carry out product innovation. In addition, the study provides practical teaching cases for design education. The design strategy system can be directly applied to curriculum teaching and graduation design guidance in design colleges. From the perspective of industrial upgrading, these strategies promote the children's furniture industry to transform from pursuing shape aesthetics and functional practicality to emphasizing cultural connotation and educational value. The industry evolves toward high-quality development. A new path is opened for the transformation and upgrading of the traditional furniture industry. From an educational theory perspective, this study integrates Montessori's "prepared environment" theory, Vygotsky's zone of proximal development theory, and Bruner's discovery learning theory, validating the educational value of the material environment as the "third teacher." The implications for early childhood education practice include: teachers can incorporate New Chinese-style desks into classroom learning centers to create "traditional culture exploration zones," using environmental cues to guide children's autonomous learning; in curriculum design, classification and cognition activities can be developed based on the desk's culturally themed storage system, and replaceable themed panels can be utilized for implementing thematic teaching on solar terms, festivals, and other topics; regarding home-school co-education, the desk's gamified teaching functions provide a vehicle for parent-child cultural interaction. Teachers can guide parents to use the desk for weekly "cultural story time" sessions. It is recommended to develop accompanying teacher manuals and parent guidebooks to transform the design into systematized educational resources.

5.3. Analysis of influencing factors of cultural enlightenment effect

The study finds that cultural enlightenment effect is influenced by multiple factors interacting. The moderating effect of these factors is significant. Individual differences among children are the primary influencing factor. Age differences are manifested as follows. The recognition rate of traditional patterns by the 5-6 age group (86.5%) is 65.2% higher than the 3-4 age group (52.3%). This suggests that design should adopt differentiated strategies. The complexity of cultural symbols should be simplified for younger children. Gender differences are mainly reflected at the preference level. Girls' emotional score for the phoenix symbol (4.18) is significantly higher than boys (3.45). There is no obvious difference in geometric patterns such as auspicious cloud and ruyi patterns. This indicates that gender-stereotyped cultural symbols should be used with caution. The moderating effect of children's original cultural foundation cannot be ignored.

Children from high cultural atmosphere families have baseline cultural cognition scores 48.5% higher than low atmosphere families. Their acceptance and learning efficiency of New Chinese-style desks are also higher. This shows that design effect depends on the cultivation of family cultural soil. Among family environment factors, the influence of parental participation is most critical. High participation amplifies design effect by 1.8 times. Under low participation conditions, the effect is greatly weakened. This highlights that cultural enlightenment cannot rely solely on material environment. Adult guidance and accompaniment are necessary. Parents' own cultural value recognition has a prediction coefficient of 0.61 for children's cultural attitudes. This far exceeds 0.38 for physical environment. The core position of role model demonstration in intergenerational inheritance is verified [54].The appropriateness of design element configuration is directly related to effect realization. Traditional element density exceeding 40% leads to excessive cognitive load. Below 20% lacks sufficient stimulation. Medium density (25-35%) constitutes the optimal interval. The age-appropriateness of cultural content selection is equally critical. Cultural concepts that are too abstract, such as "unity of heaven and man", are difficult for young children to understand. Concrete auspicious animals and seasonal phenology content have high acceptance. The catalytic effect of peer influence cannot be underestimated. When children observe peers showing interest in traditional culture, their own learning motivation increases by 156.7%. This provides strategic insights for carrying out cultural education in kindergarten collective environments.

5.4. Research limitations and future directions

This study has the following limitations, which also point to future research directions: First, the sample is limited to developed cities in eastern China. Future research should extend to central and western regions, rural areas, and families from different cultural backgrounds to test the cross-cultural applicability of the design strategies. Second, the study focuses on preschool children aged 3-6; differentiated applications of cultural design principles for infants and toddlers aged 0-3 and school-age children aged 6-12 remain to be explored. It is recommended to construct a cultural design framework for children's furniture across all age groups. Third, the research settings are limited to homes and kindergartens; future studies could expand to public educational spaces such as children's libraries and museums. Additionally, the three-month intervention period is relatively short; it is recommended to conduct longitudinal follow-up studies of 1-2 years to examine the long-term effects and developmental trajectories of cultural enlightenment. Finally, future research could explore the deep integration of digital technologies (AR/VR) with traditional cultural elements to develop intelligent cultural pedagogical furniture systems.

6. Conclusion

This study systematically explores the promotion effect of traditional cultural elements in New Chinese-style desk design on cultural enlightenment of children aged 3-6 through theoretical discussion, design practice, and empirical verification. The following core conclusions are drawn:

(1) Children aged 3-6 exhibit a progressive improvement in cognitive ability for traditional cultural elements as they age. The 5-6 age group achieved an 86.5% recognition rate for traditional patterns, demonstrating potential to accept more complex cultural symbols, while data from the 3-4 age group suggest the need for highly simplified visual presentations.

(2) Research data on the effective application of traditional cultural elements suggest that the "moderation principle" may be more effective. Favorable outcomes were observed when elements comprised 25-35%, activated three sensory channels, and integrated 3-4 pedagogical functions. Both excessive and

insufficient use may diminish enlightenment effects, though this requires further verification in larger samples.

(3) There is an association between New Chinese-style desk design and enhancement of children's cultural cognition. The experimental group showed a three-month improvement of 69.6%, higher than the control group's 27.0%. However, potential influences of confounding variables such as family education and children's natural development must be considered. The net effect of the experimental treatment is approximately a 42.6 percentage point increment, and long-term follow-up indicates that effects may attenuate to 65-70% of initial levels.

(4) Sociopsychological environmental factors demonstrate significant moderating effects. Parental involvement, family cultural atmosphere, and peer modeling effects interact with the physical environment to influence enlightenment outcomes. Data indicate that social support systems play an important role in the cultural education process, and design interventions need to coordinate with the social environment to achieve optimal effectiveness.

(5) The pedagogical design strategy system constructed in this study demonstrates practical operability and can provide reference theoretical foundations and practical guidance for developing the cultural-educational functions of children's furniture, helping to promote industry attention to the cultural-educational value of products. However, the universality and long-term effectiveness of these strategies still require further testing in different cultural contexts and usage scenarios.

Conflict of interest

The authors declare no conflicts of interest.

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