The Study of Children's Preferences for the Design Elements of Learning Desks Based on AHP-QCA

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Children's study tables are an integral part of a child's learning life. Consumers are often attracted to their styling when deciding on the use and purchase of a children's study desk. This study focused on consumption preference for the styling of children's study desks and delved into the factors that influence these preferences. An important aspect of this research is to understand how different shapes of children's desks influence consumer preferences through morphological analysis. The study breaks down these desks into six different parts based on morphological analysis: backplane, bookshelves, desktop, cabinet, drawer, and table legs. Through a hierarchical analysis (AHP) and pairwise comparisons, the study created a hierarchy of preferred morphological elements. The hierarchy ranked the importance of each element in influencing consumption preference, revealing the order of preference from backsplash to table legs. In addition, by integrating personal interviews and employing Qualitative Comparative Analysis (QCA), this study provides insights into the most preferred components – backplane and bookshelves. This integrated approach revealed a preference for desks with curved backsplashes and multi-tiered functional shelves, which was ultimately validated by successfully combining weighted rankings of specific component styles.

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Keywords: Children's Study Desks; Morphological Analysis; Analytic Hierarchy Process; QCA

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INTRODUCTION

The styling preferences of children's desks have become a compelling area of research in recent years, with the growing emphasis on homeschooling and home design concepts. Consumers and designers are increasingly concerned about the design of children's study desks, especially their styling, as it directly affects children's comfort and perception of space (Wang 2021). Numerous researchers have delved into the field of furniture form design, especially for children's study tables. They have not only studied the topic extensively but have also worked to find more scientific solutions. The goal of these studies is to enhance learning efficiency and promote the healthy growth of children, while meeting the continued growth of societal needs.

In exploring the field of furniture form design, a range of academic studies have provided insights. Beginning with Liu's (2004) in-depth exploration of the diversity and classification of furniture forms, he proposed the concepts of realistic and conceptual forms and subdivided furniture forms into eight categories: traditional, functional, stylistic, colourful, decorative, structural, material, and craft forms, which emphasised the complexity and plurality of furniture design. Chi and Liu (2004) emphasised the indoor environmental morphological characteristics and design objectives of furniture in "Muddling Into One - The Overall Morphological Design of Furniture," focusing on the creation of a harmonious indoor space and the perfect expression of furniture form. Tang and Liu (2005) discussed the theory and method of furniture form design in "Lectures on Furniture Design (VII) Furniture Form Design," which emphasised the shape and demeanour of the object form and its psychological characteristics and put forward the design method of incorporating the characteristics of natural forms. Liu (2009) showed the relationship between furniture modelling elements and emotional evaluation, providing theoretical support for emotional furniture design. Zhang's (2011) study delved into the various aspects of paper furniture design, demonstrating the diverse choices in structural design. Together, these studies form a comprehensive theoretical and practical foundation for the morphological design of children's furniture, covering a wide range of areas from material selection to emotional design.

In a study of the design of children's study tables, Knight and Noyes (1999) revealed a significant impact of learning desk and chair design on children's seating posture. The work emphasized the importance of ergonomic furniture design in preventing children's back problems and improving concentration. The work of Qin *et al.* (2015) focused on the role of study desks in supporting the healthy development of children's bones, particularly during the critical growth and developmental stage of 8 to 14 years of age. This study emphasized the impact of correct or incorrect sitting posture on children's long-term health, promoting the design of study desks that better meet children's physiological developmental needs. Ye's (2018) study, on the other hand, looked at the application of ergonomics in the design of children's study desks. By analyzing the physiological and psychological characteristics of preschool children, she proposed a series of ergonomics-based design recommendations aimed at improving the functionality and comfort of study tables. The studies by Jing *et al.* (2019) and Sheng and Sun (2019) extended their perspectives to functional design and market demand. They not only considered the practicality and durability of the study table, but also explored how to make the design fit the aesthetic and spatial requirements of modern families. The studies by Wang (2021) and Li (2021) point to the use of community shared environments and smart technologies in the design of children's study tables. Wang (2021) focuses on how to improve the efficiency of resource utilisation through community sharing, while Li (2021) explores the potential of smart learning desks in monitoring and improving children's sitting posture, and preventing myopia and hunching through the application of smart technologies. Ren *et al.* (2022) explored the effect of desktop inclination on children's forward sitting behaviour in ambulatory work. Zheng (2021) explored children's online learning needs at home, with parental accompaniment as the core perspective for design innovation. Li (2022) focuses on the design of study tables for preschool children, addressing the problems of product homogenization, single service, and poor sustainability. Zhang (2022) investigated the role of learning desks and chairs in preschoolers' health.

These studies have explored the design of children's study desks from a variety of perspectives, including technology integration, health and ergonomics, functional design, social and environmental sustainability, and the application of smart technologies, highlighting the complexity and multidimensionality of the design of children's learning environments, but there is a lack of research on children's study table furniture styling preferences.

In this paper, the hierarchical analysis method (AHP), morphological analysis, and QCA method were used to study the preference of children's desk users by starting from the characteristic elements of children's desks and conducting an in-depth analysis of the overall preference weights of each element. The goal was to provide designers with a comprehensive reference to promote the design and development of children's study desks, dig deeper into children's preference characteristics for study desk shapes, and provide substantial guidance and suggestions for optimising study desk design and enhancing the learning experience.

EXPERIMENTAL

Experimental Process

A learning desk involves numerous morphological and functional elements, and the key factors for purchasing decisions regarding these desks are highly complex, which depend on individual preferences, cultural differences, age, education level, income level, and other factors, making it challenging to conduct quantitative analysis. This study investigated and interviewed children between 10 and 15 years old, also adults with college education and experts who are professors. Their incomes are mid-level. Morphological analysis was combined with the Analytic Hierarchy Process (AHP) to help identify potential optimal solutions for children's desk designs and develop optimal decision-making strategies. Finally, the QCA analysis method was employed to evaluate the effectiveness of multiple morphological combination solutions.

Morphological analysis was proposed by the Swiss astronomer Fritz Zwicky. This is also known as shape synthesis and is widely used in various fields (Zwicky 1948; Belaziz *et al.* 2000). It is a method of decomposing a problem, dealing with its components separately, and combining these to produce multiple overall solutions, each of which needs to be assessed for feasibility.

The Analytic Hierarchy Process (AHP) is a quantitative analysis method that decomposes problems into different levels, then, using expert judgment or mathematical methods, determines the weights of factors at each level. It eventually derives the best decision. Key steps include establishing a hierarchy structure, determining judgment matrices, calculating weights, and conducting consistency tests (Vaidya and Kumar 2006; Huang *et al.* 2023). Qualitative comparative analysis (QCA) is a method of analysing data sets consisting of binary variables that was first proposed by Charles Ragin in 1987 (Ragin 2014). The basic concept is to compose such data using Boolean functions. Meanwhile, Ragin (2008) extended the method to allow the construction of fuzzy set relations; further extensions allow the handling of variables with more than two values. The flowchart in Fig. 1 details the complete steps of the study from the initial selection of products and morphological analyses to drawing conclusions through personal interviews.

This study employed two experimental methods: questionnaire surveys and interviews, encompassing three experiments. Each participant was provided with a quiet, undisturbed environment and a questionnaire containing basic information about the respondents (such as age, gender, and educational background). The first experiment involved subjective preference ratings (on a 1 to 9 scale) for the styles of components of children's study desks. Following the questionnaire survey, interviews were conducted with users regarding their preferences for the morphology of children's study desks. The second experiment focused on ranking the styling preferences of combined children's study desk designs. Lastly, the third experiment involved an evaluation questionnaire on the combination of preference factors.

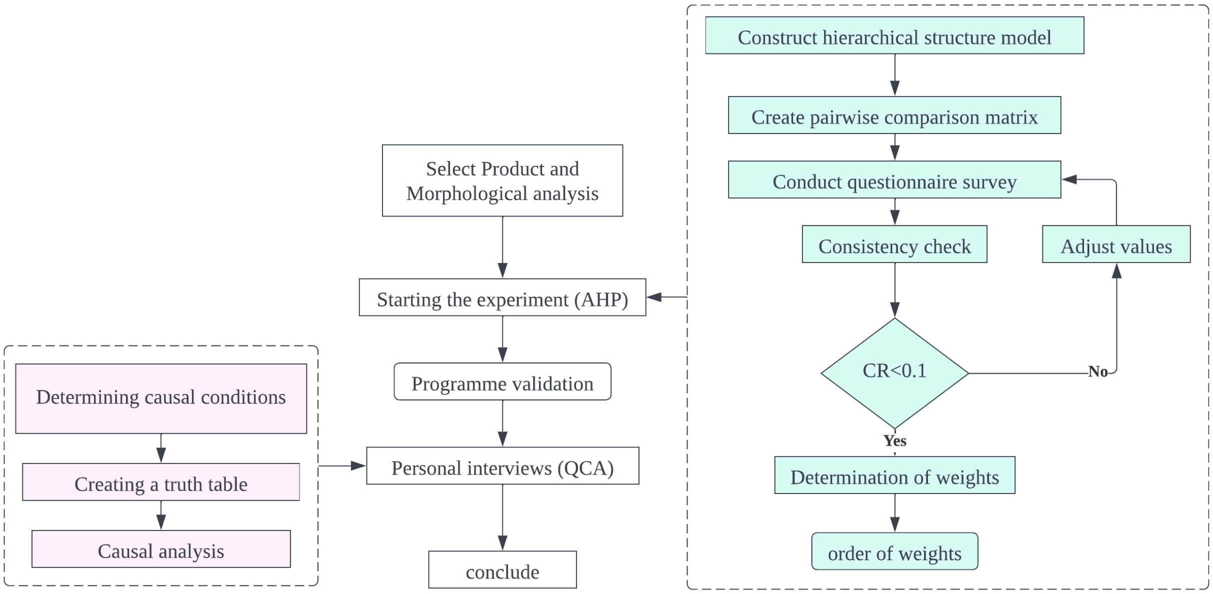


Fig. 1. Experimental process

Morphological Analysis

Morphometric analysis is a method of analysing things on the basis of morphology. It is characterised by dividing the object of study or the problem into a number of basic components, and then treating one of the basic components separately. Various solutions or options for solving the problem are provided separately, and finally a total solution to the whole problem is formed. The usual steps of the morphological analysis method: 1. Define the problem (invention, design) to be solved by this technique; 2. List the independent factors related to the problem to be solved in terms of basic components such as important functions; 3. List in detail the elements contained in each independent factor; and 4. Arrange and combine the elements into a creative idea (Nguyen 2016).

The samples of this study come from well-known brands of children's study desks on the market, including Dajiangzuo, Guangming Yuandi, Black and White, Hutong, Compule, Palmer, Qisehua, Xihao, *etc*. 30 samples that met the requirements were finally obtained after screening 50 pictures of children's study tables. In order to ensure that the selected children's study table samples meet the research needs, the study developed the following selection criteria: 1) The structure of each part of the study table in the sample should avoid having overly complex surface patterns. 2) Each component of the study table in the sample exists as an independent element and does not affect each other. 3) The study table elements in the sample should avoid adopting particularly strange shapes, such as animal shapes, *etc*. 4). The selection of study table elements within our sample was diligently curated to ensure diversity, avoiding excessive repetition or similarity. This process entailed a thorough evaluation by experts in the field, resulting in the careful selection of 18 distinctive children's study tables. The assessment team, composed of professionals from the furniture design industry, was chosen with precision to align their deep-rooted expertise with the pivotal objectives of the research. The samples underwent a stringent screening process, not only to encompass a broad spectrum of design features prevalent in the market, but also to fulfill the particular criteria of our study. This approach guarantees that the assessment outcomes will be both exhaustive and reflective of a wide-ranging consumer base. The main reason for choosing these particular brands is that they hold a considerable share of the children's study table market and represent the purchasing tendency of mainstream consumers. However, it is also recognized that there may be limitations in focusing only on well-known brands, which may lead to the so-called brand effect, which may influence consumers' purchasing decisions, and this should be taken into account in future research.

In the morphological analysis, the research object is divided into basic components, and then each part is processed separately, reorganized, or combined into various possible solutions or programs, and formed into a matrix that can solve the problem. Morphological analysis was conducted on the 18 selected children's study tables. First, each table was disassembled, as shown in Fig. 2. They were divided into six parts: backplane, bookshelves, desktop, drawer, cabinet and table legs.

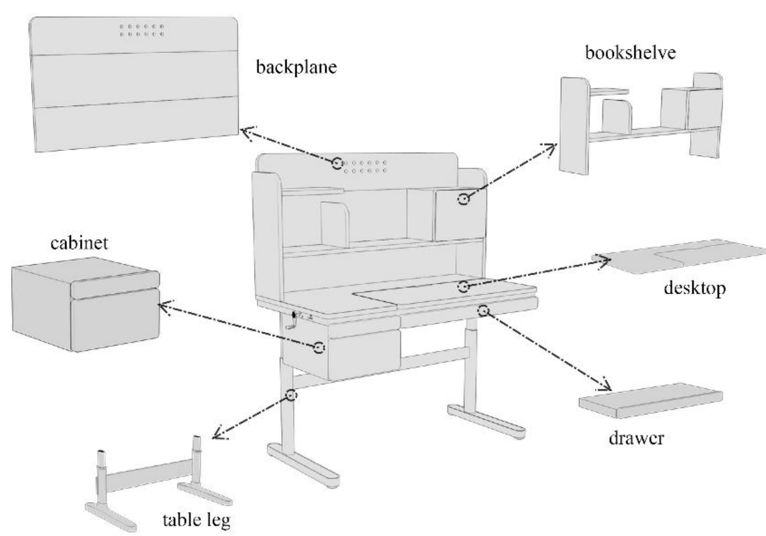


Fig. 2. Dismantled display of children's study table shape

The six components of the study table were broken down according to functional characteristics for an exhaustive analysis. In particular, the back of the study table is designed to optimise presentation, with some of the back designs including side panels, but the shape of the side panels will be determined by the design of the bookcase in the final combined design. The desk cabinets are designed to be side-mounted to save space and enhance accessibility, while the drawers are located underneath the desktop for easy access to small school supplies while the child is seated. Because this study mainly studied the shape design selection preferences of children's study desks, some connection structures that are not closely related to the research are ignored, including connectors, hidden support structures, *etc*., and the materials and colors were also unified as gray wireframe display. Separate modeling and rendering of the disassembled morphological styles were carried out. Steps of morphological analysis in this paper:

1. Determine the functional characteristics of the study table within the acceptable range after splitting (as in Table 1).
2. List the independent factors, *i.e.*, the six parts of the study table, in a diagrammatic table based on the functional features (*e.g.*, Fig. 2).
3. Create a table listing the acceptable sub-solutions within each feature (*e.g.*, Table 2).
4. Combine the options and select the best solution.

Table 1 describes the functional details of the six selected characteristic elements of children's study tables, designs, and lists solutions for each morphological element accordingly. As shown in Table 2, the backplane is designed into 9 types, G1-G9, according to the linear shape. The bookshelves were assigned into 7 styles H1 through H7 according to the different number of partition layers, the desktop was divided into 4 styles J1 through J4 according to the functional board division design, and the drawer was divided into 3 styles (K1 to K3) according to the bridge between the external linear shape and the table board. For the styles, the cabinet was divided into 7 styles (L1 through L7) by means of different cabinet surfaces and using methods, and the table legs were divided into 7 styles (M1 through M7) according to different table leg types and cross brace types.

Brand effects may lead to user preferences that do not reflect the actual functionality and design of the product, and focusing on well-known brands may overlook design innovations. To reduce this bias, future research should broaden the sample to cover brands of different popularity, clearly analyzing brand effects, and assessing user preferences more realistically through blind tests.

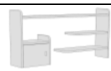
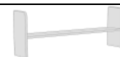
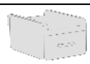
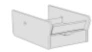
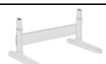
Table 1. Functional Description of the Characteristic Elements of Children's Study Desks

Element	Functional Description
Backplane	The back panel of a study table, usually located at the rear of the table, used to support the desktop and increase the structural stability of the table
Bookshelves	Storage racks on study desks for storing books, stationery and other study supplies
Desktop	Usually used for writing, painting, computer use and other activities
Drawer	Usually located in the front of the desk, is used to store stationery, books, documents and other items
Cabinet	Usually located under the desk, can have drawers or doors and is used to store large items or archive documents, *etc*.
Table leg	Support for the entire desktop and other components

Constructing a Hierarchical Model Using AHP

AHP is a quantitative analysis method based on Judgment matrix, which is used to solve complex decision-making problems and help decision-makers make trade-offs and choices among multiple factors. According to the desk morphological structure and the morphological preference decision-making problem that is the aim of this study, the target layer is children's learning desk morphological preference, and we defined a hierarchical structure model including different components. Criterion hierarchy includes six parts: backplane (U1), bookshelves (U2), desktop (U3), drawer (U4), cabinet (U5) and table leg (U6). These were designed according to the design plan in the previous chapter: Indicator hierarchy ensures the orderliness and layering of the hierarchy, making decision-making easy to manage.

Table 2. Form Elements of Children's Study Tables

Form Element	Style 1	Style 2	Style 3	Style 4	Style 5	Style 6	Style 7	Style 8	Style 9
Backplane	 G1	 G2	G3	 G4	 G5	G6	 G7	 G8	 G9
Bookshelves	 H1	 H2	 H3	 H4	 H5	 H6	 H7		
Desktop	J1	 J2	J3	 J4					
Drawer	 K1	 K2	 K3						
Cabinet	 L1	 L2	 L3	 L4	 L5	 L6	 L7		
Table leg	 M1	 M2	 M3	 M4	 M5	 M6	 M7		

Preference scoring was carried out by children aged 10 to 15 years and by adults over 25, with 25 children and 25 adults (including 5 experts who come from College of Furnishings and Industrial Design, Nanjing Forestry University), in total 50.

Figure 3 shows the structural hierarchy model. The subject selection logic was designed to capture the preferences of the target user group (children) while incorporating the insights of adults (including experts) to ensure that the findings are comprehensive and balanced. This approach helped to develop a comprehensive understanding of children's study table design preferences, which in turn guided a more effective product design and decision-making process.

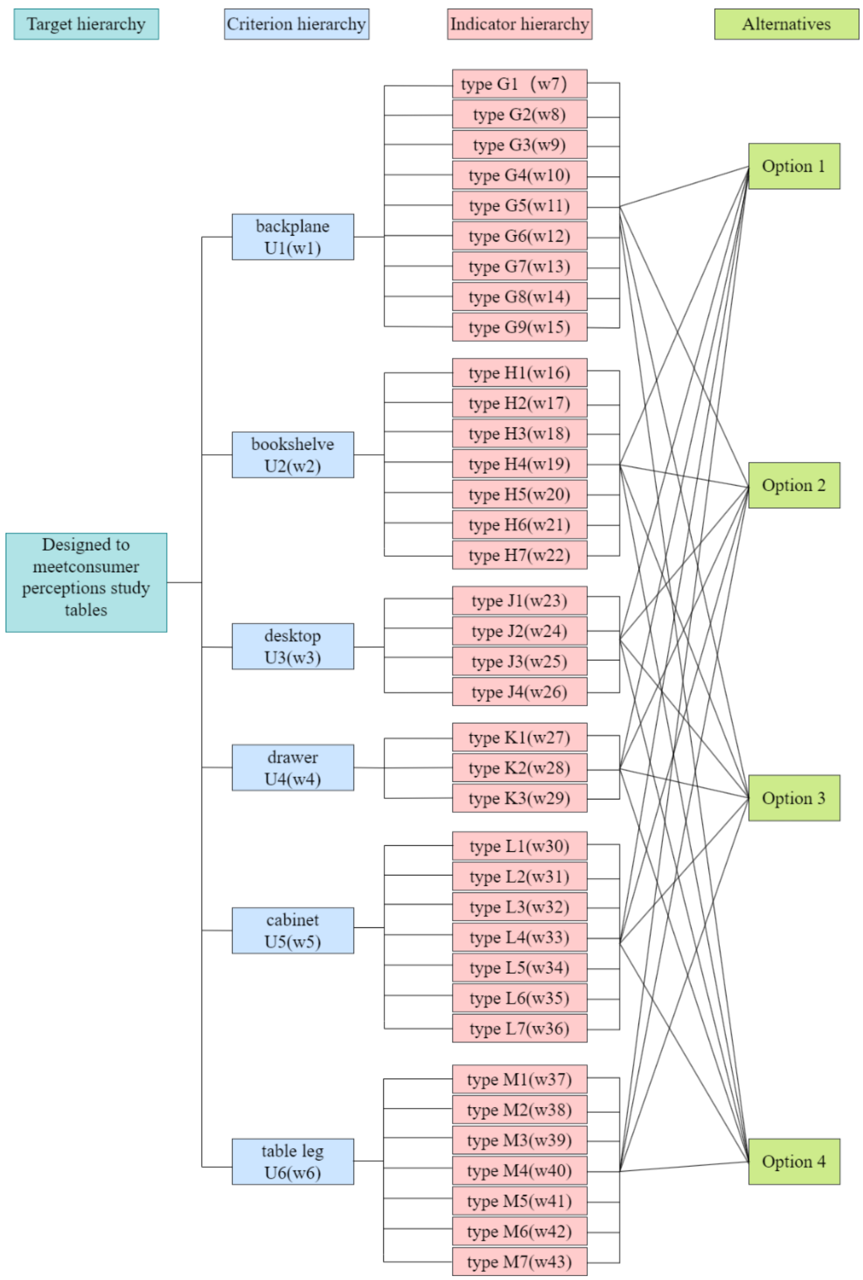


Fig. 3. Form preference of hierarchical model of study desk

Constructing Pairwise Comparison Matrix

Constructing a judgment matrix is an important step in AHP, and the scoring system of 1 through 9 is a recognized universal standard (Saaty 1987). If there are too many levels, it will lead to inaccurate judgment because it exceeds the scope of judgments of people, thus providing unreliable data. Researchers such as Saaty also used experimental methods to compare the accuracy of people's judgments on various scales. The results showed that judgments on a scale of 1 to 9 are most appropriate. Table 3 shows the scoring scale and definition of the first-level indicator criterion level, and the scoring and definition of the second-level indicator target level.

Table 3. Meaning of the Indicator Scoring Scale

Scaling	Definition
1	Indicates that two factors have the same importance compared to each other
3	Indicates that compared with two factors, the former is slightly more important than the latter
5	Indicates that compared with two factors, the former is more important than the latter
7	Indicates that compared with two factors, the former is obviously more important than the latter
9	Indicates that compared with two factors, the former is much more important than the latter, to an extreme degree
2, 4, 6, 8	Represents the intermediate value of the above adjacent judgments
Reciprocal	If the ratio of the contribution of element i to element j is a_{ij}, then the ratio of the contribution of element j to element i is $a_{ji}=1/a_{ij}$

A pairwise comparison between two parameters (such as parameter i and parameter j) was used to assess their relative importance. According to Table 1, each judgment was recorded in the form of a pairwise comparison matrix a of dimension n × n, where n is the number of parameters to be compared and parameter b_{ij} is the result of comparing the contribution of parameter bi and parameter b_j to the previous level. The pairwise comparison matrix A is presented as Eq. 1.

$$A=\begin{bmatrix} b_{11}\, b_{12} \cdots b_{1n} \\ b_{21}\, b_{22} \cdots b_{2n} \\ \dots\ \ \dots\ \cdots\ \dots \\ b_{n1}\, b_{n2} \cdots b_{nn} \end{bmatrix} \tag{1}$$

Consistency Evaluation

To determine whether the weights obtained by the matrix are reasonably distributed, it was necessary to conduct a consistency test on the judgment matrix. The calculation is shown in Eq. 2,

$$CR = \frac{CI}{RI} \tag{2}$$

where CR is the random consistency ratio of the judgment matrix and RI is the average random consistency index of the judgment matrix. The RI values of judgment matrices of orders 1 to 9 are shown in Table 4. CI is the consistency index of the judgment matrix, calculated by Eq. 3,

$$CI = \frac{\lambda_{max}-n}{n-1} \tag{3}$$

When the CR<0.1 of the judgment matrix A or when λ_{max} = n, CI=0, A is considered to have satisfactory consistency, otherwise the elements in A need to be adjusted to make it have satisfactory consistency.

Table 4. RI Indicators of Judgment Matrix

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41	1.46

QCA Method

The initial step in QCA for the research question "what factors lead to styling preferences" involves specifying causal conditions that have a significant impact on styling preferences. Next, a truth table is constructed using data on causal conditions and styling preferences from the selected cases. The truth table lists all logically possible combinations of conditions and their associated outcomes. In addition, the truth table provides a detailed description and formal framework for the case checking process. By examining the truth table, diversity studies can be conducted to identify common and rare configurations.

In the second step, the analysis of causal adequacy, the so-called "truth table solution" provides a list of combinations of causal factors that satisfy specific adequacy criteria. This involves evaluating the results with an affiliation score that is always higher than the score of the causal combination. The truth table algorithm takes into account both the degree of inconsistency and causal conditions or combinations with strong affiliation. To construct the truth table, csQCA lists all logically possible combinations of conditions, including those for which there are no empirical examples. The consistency score serves as a measure of subset relationships, and QCA analyses the extent to which particular causal factors or configurations are subsets of modelling preferences (Cotte Poveda and Pardo Martínez 2013).

To analyze the impact of form factors on consumer preferences, after using the AHP method to obtain the form preference ranking of the components of children's study tables, qualitative analysis, and comparison (QCA) were used to analyze the form of the two components with higher weights. This study adopted the QCA steps as follows:

1) First, determine and identify important causal conditions related to morphological elements through interviews, which are independent variables. 50 subjects were interviewed to understand their preferences and reasons. Their choice of form preference was summarized through the interview results, which is the dependent variable.

2) A truth table is a tool used to demonstrate various combinations of conditions and their relationships to outcomes in selected cases. Create a truth table based on the inductive morphological preference elements, listing the different combinations of conditions associated with them and the associated possible situations.

3) Construct a truth table and analyze the solutions of the truth table, and evaluate the consistency and coverage to determine the direct relationship between elements and the required morphological element results. Coverage and Consistency tests are shown as Eqs. 4 and 5, respectively.

$$\text{Coverage } (Xi \geqslant Yi) = \sum[\min(Xi,Yi)]/\sum(Yi) \tag{4}$$

$$\text{Consistency } (Xi \leqslant Yi) = \sum[\min(Xi,Yi)]/\sum(Xi) \tag{5}$$

In this formula, the min(X) is the intersection ("AND" or $\cap$) of all X. $\sum(X)$ is the union (“OR”or ∪) of all X. When membership in outcome Y is less than membership in causal configuration X, the numerator will be smaller than the denominator and the consistency score will decrease. “Consistency scores range from 0 to 1, with 0 indicating no subset relationship and a score of 1 denoting a perfect subset relationship (Epstein *et al.* 2008).” Instead, coverage applies to the proportion of the sum of member scores in the results explained by a particular configuration.

The consistency score is a measure of how consistent a structure is, a measure of subset relationships. The extent to which a specific causal factor or configuration is considered a subset of an outcome in QCA analysis, and the consistency score quantifies this subset relationship. If the consistency calculation result is greater than 0.9, then the factor is considered necessary; otherwise it is not necessary. Coverage is a measure for judging the relationship between causal configuration and results. A high coverage score indicates that the configuration is consistent with the result, and there are more configuration results that are “in”; on the contrary, a low coverage score indicates that even if the causal configuration is consistent with the result, it does not have substantial impact. Studying coverage scores helps the investigator to avoid spurious configurations of selected results.

RESULTS AND DISCUSSION

Calculation and Consistency Test of Preference Weights in Analytic Hierarchy Process

First-level indicator weight calculation and consistency test

The subjects were invited to fill in 7 judgment matrices, and the data at the same position in the same matrix were arithmetically averaged to obtain 7 judgment matrices. This study used the root method to calculate the weight. The steps were: firstly, the columns were normalized in the element matrix. Then the eigenvalues and corresponding eigenvectors of the standardized judgment matrix were calculated. Finally, the eigenvalue represented the relative value and importance of the judgment matrix. The eigenvector represents the weight vector of the corresponding eigenvalue. The feature vectors were normalized so that the sum of all weights was equal to 1, giving the final weight for the vector. The decision-maker's preference for the shape of the children's study table is reflected in the judgment matrix of the decision-maker's pairwise comparison of each component. By comparing the judgment matrices, the preference weight of the shape of each component relative to the overall appearance of the children's table can be calculated. The judgment matrix and component preference weights are shown in Table 5.

Table 5. Component Preference Weights

	Backplane	Bookshelves	Desktop	Drawer	Cabinet	Table leg	Weight (wi)
Backplane	1	1.9063	1.5804	1.8556	2.4175	2.9471	0.2843
Bookshelves	0.5246	1	1.7952	2.3222	2.7222	1.1444	0.2118
Desktop	0.6328	0.557	1	2.0127	1.8397	2.172	0.183
Drawer	0.5389	0.4306	0.4968	1	0.7852	1.5111	0.1104
Cabinet	0.4137	0.3673	0.5436	1.2736	1	2.0079	0.1187
Table leg	0.3393	0.8738	0.4604	0.6618	0.498	1	0.0917

Among the first-level indicators, the backboard preference weight accounted for 28.43%, ranking first, indicating that users attach the highest importance to the backboard in the study table form design. The bookshelf preference weight accounted for 21.18%, which shows that users are also very concerned about the design of bookshelf. The preference weights of the desktop, drawers, table cabinets and table legs accounted for 18.3%, 11.04%, 11.87% and 9.17% respectively, demonstrating the relative contribution of these design elements in the overall form design of the children's table. This weight distribution result provides clear guidance for the design of children's study tables, helping to pay more attention to the user's morphological preferences during the design process.

Results in Table 5 were subjected to consistency (CR) testing as follows:
λ_{max}=($\sum$(Aw/w))/n=6.2526; RI=1.26; n=6; CI=(λ_{max}-n)/(n-1)=(6.2526-6)/(6-1)=0.0505
CR=CI/RI=0.0505/1.26=0.0401; Because 0.0401<0.1, the results were judged to have satisfactory consistency.

In the preference for the overall shape of the children's study table, the components were ordered as backboard > bookshelf > tabletop > table cabinet > drawer > table legs.

Secondary indicator weight calculation and consistency test

Tables 6 through 11 show the judgment matrix for the comparison of preference weights between styles among the six feature elements. The six matrices were calculated according to the above data processing method, and a consistency check was performed. Each style weight is summarized according to the corresponding position, as shown in Table 12.

Table 6. Backplane Style Weights

Backplane	G1	G2	G 3	G 4	G 5
G 1	1	1.4778	1.8556	1.0333	2.0286
G 2	0.6767	1	1.7079	0.8841	0.6868
G 3	0.5389	0.5855	1	2.573	3.2556
G 4	0.9678	1.1311	0.3887	1	2.4333
G 5	0.493	1.456	0.3072	0.411	1
G 6	0.5371	0.483	0.5185	0.7	0.3704
G 7	0.6526	0.5585	0.3808	0.35	0.5151
G 8	0.5357	0.7283	0.4206	0.5655	0.3846
G 9	0.3543	0.3752	0.3061	0.3614	0.4762

Backplane	G 6	G 7	G 8	G 9	Weight (wi)
G 1	1.8619	1.5323	1.8667	2.8222	0.1666
G 2	2.0704	1.7905	1.373	2.6656	0.1304
G 3	1.9286	2.6259	2.3778	3.2667	0.1701
G 4	1.4286	2.8571	1.7683	2.7667	0.1421

G 5	2.7	1.9413	2.6	2.1	0.1129
G 6	1	2.6704	1.8111	3.4286	0.0955
G 7	0.3745	1	3.346	3.0635	0.0783
G 8	0.5522	0.2989	1	2.4333	0.0633
G 9	0.2917	0.3264	0.411	1	0.0408

Regarding Table 6, the consistency calculations are: λ_{max}=(∑(Aw/w))/n=9.8619; RI=1.46; n=9; CI=(λ_{max}-n)/(n-1)=(9.8619-9)/(9-1)=0.1077; CR=CI/RI=0.1077/1.46= 0.0738; According to the calculation, CR=0.0738<0.1, so it has satisfactory consistency.

Table 7. Bookshelves Style Weights

Book-shelves	H1	H2	H 3	H 4	H 5	H 6	H 7	Weight (wi)
H 1	1	2.8059	1.8872	1.7509	2.3888	2.463	3.0426	0.2736
H 2	0.3564	1	1.1248	1.7905	2.4	1.1888	0.421	0.1291
H 3	0.5299	0.889	1	0.9245	3.1179	2.4444	1.2513	0.1616
H 4	0.5711	0.5585	1.0817	1	3.135	2.0117	2.1631	0.1645
H 5	0.4186	0.4167	0.3207	0.319	1	1.811	1.327	0.0841
H 6	0.406	0.8412	0.4091	0.4971	0.5522	1	2.4571	0.0941
H 7	0.3287	2.3753	0.7992	0.4623	0.7536	0.407	1	0.0932

Consistent CR solution: λ_{max}=(∑(Aw/w))/n=7.7362; RI=1.36; n=7;
CI=(λ_{max}-n)/(n-1)=(7.7362-7)/(7-1)=0.1227; CR=CI/RI=0.1227/1.36=0.0902
According to the calculation, CR=0.0902<0.1, so it has satisfactory consistency.

Table 8. Desktop Style Weights

Desktop	J1	J 2	J 3	J 4	Weight (wi)
J 1	1	1.356	2.8496	1.6007	0.3651
J 2	0.7375	1	2.7529	1.8513	0.3223
J 3	0.3509	0.3633	1	1.4254	0.1511
J 4	0.6247	0.5402	0.7016	1	0.1615

Consistent CR solution: λ_{max}=(∑(Aw/w))/n=4.1078; RI=0.89; n=4
CI=(λ_{max}-n)/(n-1)= （4.1078-4)/(4-1)=0.0359; CR=CI/RI=0.0359/0.89=0.0404
According to the calculation, CR=0.0404<0.1, so it has satisfactory consistency.

Table 9. Drawer Style Weights

Drawer	K1	K 2	K 3	Weight (wi)
K 1	1	1.4559	1.6908	0.4211
K 2	0.6869	1	3.0173	0.3977
K 3	0.5914	0.3314	1	0.1812

Consistent CR solution: λ_{max}=(∑(Aw/w))/n=3.1021; RI=0.52; n=3
CI=(λ_{max}-n)/(n-1)= （3.1021-3)/(3-1)=0.0511; CR=CI/RI=0.0511/0.52=0.0982
According to the calculation, CR=0.0982<0.1, so it has satisfactory consistency.

Table 10. Cabinet Style Weights

Cabinet	L1	L2	L3	L4	L5	L6	L7	Weight (wi)
L1	1	2.2212	1.4683	2.6878	1.5519	1.7111	0.9397	0.208
L2	0.4502	1	1.7524	2.5905	1.6952	2.1815	1.6534	0.192
L3	0.6811	0.5706	1	2.2593	0.8619	2.0741	2.9508	0.1666
L4	0.3721	0.386	0.4426	1	1.4386	1.0952	1.6175	0.1032
L5	0.6444	0.5899	1.1602	0.6951	1	3.9444	3.6508	0.1655
L6	0.5844	0.4584	0.4821	0.9131	0.2535	1	1.0841	0.082
L7	1.0642	0.6048	0.3389	0.6182	0.2739	0.9224	1	0.0826

Consistent CR solution: λ_{max}=(∑(Aw/w))/n=7.6308; RI=1.36; n=7
CI=(λ_{max}-n)/(n-1)= (7.6308-7)/(7-1)=0.1051; CR=CI/RI=0.1051/1.36=0.0773
According to the calculation, CR=0.0773<0.1, so it has satisfactory consistency.

Table 11. Table Leg Style Weights

Table leg	L1	L2	L3	L4	L5	L6	L7	Weight (wi)
L1	1	2.2212	1.4683	2.6878	1.5519	1.7111	0.9397	0.208
L2	0.4502	1	1.7524	2.5905	1.6952	2.1815	1.6534	0.192
L3	0.6811	0.5706	1	2.2593	0.8619	2.0741	2.9508	0.1666
L4	0.3721	0.386	0.4426	1	1.4386	1.0952	1.6175	0.1032
L5	0.6444	0.5899	1.1602	0.6951	1	3.9444	3.6508	0.1655
L6	0.5844	0.4584	0.4821	0.9131	0.2535	1	1.0841	0.082
L7	1.0642	0.6048	0.3389	0.6182	0.2739	0.9224	1	0.0826

Consistent CR solution: λ_{max}=(∑(Aw/w))/n=7.4587; RI=1.36; n=7
CI=(λ_{max}-n)/(n-1)= (7.4587-7)/(7-1)=0.0765; CR=CI/RI=0.0765/1.36=0.0562
According to the calculation, CR=0.0562<0.1, so it has satisfactory consistency.

Table 12. Summary Table of Weights

Style Weight Sorting	Backplane	Bookshelves	Desktop	Drawer	Cabinet	Table Leg
1	G3	H1	J1	K1	L1	M1
2	G1	H4	J2	K2	L2	M2
3	G4	H3	J4	K3	L3	M4
4	G2	H2	J3		L5	M5
5	G5	H6			L4	M3
6	G6	H7			L7	M6
7	G7	H5			L6	M7
8	G8					
9	G9					

Questionnaire Interviews and QCA Analysis

The first two components ranked by preference weight according to the AHP method are the backplane and the bookshelves. Interviews were conducted with users on their form preferences regarding backplane and the bookshelves. The interview records and summary results are shown in Table 13. Through interviews, it was concluded that users' preference for backplane is linear, and users' preference for bookshelves is functionality. In order to accurately understand the impact of these two factors on consumers' styling preferences, this study divided functionality into the number of layers of bookshelf partitions. When the number of layers ≤ 2, concluded low functionality, and when the number of layers > 2, concluded high functionality. The division of linear shapes is mainly based on edge chamfering, which is divided into arcs and straight lines, as shown in Table 14.

The design factors were ranked and combined to obtain four cases (Straight+High, Straight+Low, Arc+High, and Arc+Low), and then each of the four cases was randomly distributed to fifty subjects for them to express a preference.

The question of this study is: What factors cause styling preferences? The dependent variables are functionality and linearity, and the following explanations are given for the independent variables:

Linear (xx) = xx = 1 if the preference factor is an arc, xx = 0 if it is a straight line.

Function (gn) = If the preference factor is high in functionality, then gn = 1, if it is low in functionality, then gn = 0.

Table 13. Interview Transcripts

Interview descripts	Specific description	Summary
Interview descriptors Versatile Complex Shapes Practical Bookshelf levels Convenient for storing items concise/simple Smooth/round lines Smooth	1. The rounded lines of the backboard have the feel of children's furniture, and the chamfering gives people a sense of safety; 2. The bookshelf has strong functionality, specifically its storage function.	1. Linear 2. Functionality

Table 14. Factor Classification

Linear	Functional
Straight line: G5,G8,H2,H3,H6,K2,K3,L1,L3,L4,L5,L6,M5,M6,M7	Low functionality: H1,H3,H4
Arcs line: G1,G2,G3,G4,G6,G7,G9,H1,H4,H5,H7,K1,L2,L7,M1,M2,M3,M4	High functionality: H2,H5,H6,H7

The preference selection results, the relationship between the dependent variable and the independent variable, and the truth table are shown in Table 15 and Table 16. Full data are shown in the appendix.

Table 15. The Relationship between the Dependent Variable and the Independent Variable

Subject No.	Preference	Linear Shape (xx)	Function (gn)
1	Dislike	Straight Line	High
2	Dislike	Straight Line	Low
3	Dislike	Straight Line	High
4	Like	Arc	Low
5	Like	Arc	High
…			
50	Like	Arc	Low

Table 16. Dependent Variable and Independent Variable Truth Table

Subject No.	Preference	Linear shape (xx)	Function (gn)
1	0	0	1
2	0	0	0
3	0	0	1
4	1	1	0
5	1	1	1
…			
50	1	1	0

Table 17 analyzes the necessity of the two preference factors, where xx represents an arc shape, ~xx represents a straight line; gn represents high functionality, and ~gn represents low functionality. If the preference factor consistency calculation result is greater than 0.9, then the factor is considered necessary. Since the consistency of the calculated linear and functional preference factors is less than 0.9, these two preference factors are not necessary, and the truth table configuration analysis continues.

The results in Table 18 show that the solution when the two preference factors of linear arc and high functionality appear at the same time is the best, with an original coverage rate of 0.483871 and a consistency of 1. This shows that consumers like children’s study tables that have both a curved shape and high functionality as a bookshelf. Due to the limitations of the study table case, there is no combination suitable for these two factors among the four combination style plans in the previous section.

Table 17. Necessity Analysis of Preference Factors

Subject No.	Consistency	Coverage
xx	0.806452	0.862069
~xx	0.193548	0.285714
gn	0.677419	0.777778
~gn	0.322581	0.434783

Table 18. Truth Table Configuration Analysis

	Raw Coverage	Unique Coverage	Consistency
xx*gn	0.483871	0.483871	1
solution coverage	0.483871		
solution consistency	1		

This study was limited in terms of sample diversity and may not have fully covered users from different socio-economic backgrounds. The selection of design elements was influenced by the researcher's subjective judgement, although the use of Analytical Hierarchy Process (AHP) attempted to reduce bias. The subjectivity of the questionnaires and interviews and the data processing limitations of qualitative comparative analysis (QCA) may also have affected the accuracy of the results. Future research will increase the representativeness of the sample and the objectivity of data collection to enhance the comprehensiveness and applied value of the study.

AHP Method Design Verification

To verify the preference weight ranking obtained by the analytic hierarchy process, based on the weight ranking calculated by the secondary indicator weight, as shown in Table 12, the highest weight, the second highest weight, the second lowest weight, and the lowest weight among each element are selected. elements, four sets of children's study table design plans are combined, namely (1) Plan 1: G9+H5+J3+K3+L6+M7; (2) Plan 2: G1+H4+J2+K2+L2+M2; (2) Plan 3: G3+H1+J1+K1+L1+M1; (4) Plan 4: G8+H7+J4+K2+L7+M6. The corresponding four options are ranked in preference, namely most preferred, second preferred, second not preferred, most not preferred. There are only three styles of drawers, so to avoid compromising the overall weight, Style 2 was chosen for both the second preferred children's study table drawer and the second not-preferred drawer.

Option 1 Option 2 Option 3 Option 4

Table 19. Design Programme Weights

Option	Option 1	Option 2	Option 3	Option 4
Backplane U1	0.0408	0.1421	0.1701	0.0783
Bookshelves U2	0.0841	0.1645	0.2736	0.0932
Desktop U3	0.1511	0.3223	0.3651	0.1615
Drawer U4	0.1812	0.3977	0.4211	0.3977
Cabinet U5	0.0820	0.1920	0.2080	0.0826
Table leg U6	0.0702	0.1452	0.2758	0.0930

The first-level indicator weight is A=[0.2843, 0.2118, 0.1830, 0.1104, 0.1187, 0.0917]

The secondary weights of the four design options are:

$$R1=[0.0408 \quad 0.0841 \quad 0.1511 \quad 0.1812 \quad 0.0820 \quad 0.0702]$$
$$R2=[0.1421 \quad 0.1645 \quad 0.3223 \quad 0.3977 \quad 0.1920 \quad 0.1452]$$
$$R3=[0.1701 \quad 0.2736 \quad 0.3651 \quad 0.4211 \quad 0.2080 \quad 0.2758]$$
$$R4=[0.0783 \quad 0.0932 \quad 0.1615 \quad 0.3977 \quad 0.0826 \quad 0.0930]$$

As a result:

$$R=\begin{bmatrix} 0.0408 & 0.1421 & 0.1701 & 0.0783 \\ 0.0841 & 0.1645 & 0.2736 & 0.0932 \\ 0.1511 & 0.3223 & 0.3651 & 0.1615 \\ 0.1812 & 0.3977 & 0.4211 & 0.3977 \\ 0.0820 & 0.1920 & 0.2080 & 0.0826 \\ 0.0702 & 0.1452 & 0.2758 & 0.0930 \end{bmatrix}$$

$$M=A*R=[0.09323834 \quad 0.21423235 \quad 0.26959111 \quad 0.13379375]$$

According to the Analytical Hierarchy Process, it can be concluded that the least favorite was Option 1, the most liked was Option 3, the second least liked was Option 4, and the second most liked was Option 2. So the order of design preference (dislike-like) is Option 1 - Option 4 - Option 2 - Option 3.

Let 50 subjects arrange the four study desks in order. The order that the subjects see here is Option 1 - Option 2 - Option 3 - Option 4. The statistical results are shown in Table 20.

Table 20. Statistical Results of Programme Ranking

	NO.1	NO.2	NO.3	NO.4
Option 1	86%	8%	4%	2%
Option 2	4%	10%	76%	10%
Option 3	4%	8%	12%	76%
Option 4	6%	74%	8%	12%

Option 1 was ranked first, and 86% of people chose not to like it. The second place was Option 4, which 74% of people chose, and the third place was Option 2, which 76% of people chose. In fourth place was option 3, chosen by 76% of people. Therefore, the preference (dislike-like) ranking of 50 people was 1-4-2-3, which was consistent with the ranking obtained by the analytic hierarchy process. Therefore, it was verified that the weight results obtained by the analytic hierarchy process can help designers accurately grasp the distribution of preferences between children and adults, thereby designing a children's study table that conforms to the user's perspective tendency.

CONCLUSIONS

1. The analytic hierarchy process was used to construct an analytic hierarchy process, and the ranking of the first-level indicator preference weights was found to be: backplane > bookshelves > desktop >cabinet > drawer > table leg.
2. Through personal interviews combined with the QCA method, an in-depth study of users' preferences for children's study desk backboards and bookshelf components was conducted. It was found that the key morphological factors that users prefer for these two components are linearity and functionality. These two design factors were rearranged and combined, and subjects were randomly selected for preference selection. It was concluded that users preferred children's study table products with high functionality and curved applications.

3. In the ranking of secondary index preference weights, the preference weights of each style are summarized according to the corresponding position to obtain four plans: (1) Option 1: G9+H5+J3+K3+L6+M7; (2) Option 2: G1+H4+J2+K2+L2+M4; (2) Option 3: G3+H1+J1+K1+L1+M1; (4) Option 4: G8+H7+J4+K2+L7+M6. Based on the weight ranking, the children's study table design scheme was combined for method verification. The preference ranking in the selected samples was Option 1 - Option 4 - Option 2 - Option 3, which were consistent with the ranking obtained by the analytic hierarchy process, indicating that this method effectively helps the decision-making and evaluation of shapes of children's desk.
4. By combining hierarchical analysis and QCA methods, this study provides an innovative analytical framework and key insights into user preferences for children's study table design, which has important implications for future product design and market research. The findings not only enhance the understanding of user needs, but also provide practical guidelines on how to incorporate functionality and morphological style in the design process. Overall, this research will drive innovation in the field of furniture design, particularly in optimising children's learning environments, providing valuable insights for future research and practice.

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APPENDIX

Schedule (complete truth table)

Subject No.	Preference	Linear shape (xx)	Function (gn)	Subject No.	Preference	Linear shape (xx)	Function (gn)
1	1	1	1	26	0	0	0
2	1	1	0	27	0	0	0
3	1	1	1	28	0	0	1
4	1	1	1	29	1	0	1
5	0	1	0	30	0	0	0
6	1	1	0	31	1	1	1
7	1	1	1	32	1	1	0
8	1	1	0	33	1	1	1
9	1	0	1	34	1	1	1
10	0	0	1	35	0	1	0
11	0	0	0	36	1	1	0
12	0	0	0	37	1	1	1
13	0	0	1	38	1	1	0
14	1	0	1	39	1	0	1
15	0	0	0	40	0	0	1
16	1	1	1	41	0	0	0
17	1	1	0	42	0	0	0
18	1	1	1	43	0	0	1
19	1	1	1	44	1	0	1
20	0	1	0	45	0	0	0
21	1	1	0	46	1	1	1
22	1	1	1	47	1	1	0
23	1	1	0	48	1	1	1
24	1	0	1	49	1	1	1
25	0	0	1	50	0	1	0