Dining Table Design Research Based on User Needs Hierarchy and DEMATEL-ISM

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This study aimed to address the demand for furniture by developing a user-oriented design pathway for intelligent furniture products, using dining tables as a case study. According to Maslow's hierarchy, the user needs are classified, and then the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method was used to calculate the causal relationship, as well as the centrality and weight of each demand. The logical relationship between these factors was analyzed with Interpretive Structural Modeling (ISM) to create a hierarchical logic diagram. To ensure the feasibility of the theoretical framework, the System Usability Scale (SUS) was used for evaluation. This study systematically sorted out the logical relationship and hierarchical structure in the table demand system and identified the core elements and factor categories in the table design. The results confirmed that this design pathway effectively met user needs for dining furniture and provided practical guidance for developing the same type of furniture products, offering valuable reference for similar design endeavors.

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INTRODUCTION

As the consumption levels of Chinese residents have increased, there has been a greater demand for household dining tables that meet public needs. The dining table is the focal point for family activities. In the dining furniture market, consumers' choices are not only limited to basic dining functions, but also incorporate the pursuit of quality of life, home style, and personal taste (Bumgardner and Nicholls 2020; Zhu and Niu 2022; Wen and Pashkevych 2023). Muhammad *et al*. (2022) conducted a comprehensive performance evaluation of reconstituted bamboo materials, including their mechanical properties and processing adaptability, establishing a solid foundation for innovative applications in the furniture industry. Xiong *et al.* (2021) used a standardized experimental study on children's solid wood furniture components to improve the standardization of solid wood components. However, the development of China's furniture industry is relatively recent and still lags behind Western countries, mainly due to a lack of scientific analysis of user needs and material applications (Fu *et al.* 2022; Tian *et al.* 2023; Li *et al.* 2024). In this context, Chinese consumers' purchasing decisions are increasingly based on high expectations for material quality, design aesthetics, and functionality. Furniture and product design can achieve sustainability through structure innovation, space flexibility, and material saving (Susanty *et al.* 2020). This research was intended to scientifically deduce and design furniture that not only aligns with Chinese consumers' aesthetic preferences but also meets the requirements for outdoor use, from the perspective of consumer expectations.

User research methods can play a significant role in furniture design (Wang and Chen 2024). To capture the needs of Chinese consumers, this study will construct a model based on Maslow's hierarchy of needs. Maslow's hierarchy of needs is a psychological theory outlining the items that people consider to be essential to their well-being (Dar and Sakthivel 2022). This framework starts with the most basic survival needs and progresses to higher-level emotional needs (Rojas *et al.* 2023). Sánchez *et al.* (2020) proposed the "Design Pyramid" model based on Maslow's hierarchy, linking the diverse needs of the elderly with the physical attributes of architectural spaces, and proposing a theoretical model for age-friendly cities and facilities. Wu *et al.* (2020) identified three main aspects and 17 indicators of healthy dormitories using Maslow's hierarchy of needs theory. Their analysis, involving questionnaire surveys and structural equation modeling, provided valuable insights and guidance for the construction of healthy dormitories. By categorizing needs using Maslow's model and conducting interviews with design experts in the wooden furniture industry, this study aims to identify the key demand elements that outdoor furniture consumers value.

The Decision-Making Trial and Evaluation Laboratory (DEMATEL), one of the MCDM methods, was developed in 1972 by the Battelle Memorial Institute of Geneva Research Center (Koca and Yildirim 2021). Karasan *et al.* (2022) combined the AHP-DEMATEL-QFD methods to weigh customer needs collected through a neutral AHP, identify corresponding technical characteristics, and analyze the interrelationships among these characteristics using the neutral DEMATEL method. This approach was applied to optimize the design of automotive seats. Singh and Sarkar (2020) proposed a hybrid framework based on the fuzzy Delphi method and DEMATEL, using the Indian automotive industry as a case study to analyze causal relationships and identify three major objectives for the development of Indian automotive brands. Combining DEMATEL with ISM addresses this limitation (Xia *et al.* 2022). RezaHoseini *et al.* (2021) combined DEMATEL and ISM to identify and analyze key factors and their interrelationships in complex construction project management, using ISM to design a hierarchical challenge network and determine the level and impact of each challenge. Chen (2021) improved upon DEMATEL and ISM theories to analyze the social insurance willingness of China's urban and rural migrant populations, identifying direct and indirect influences among factors with DEMATEL, and revealing the intrinsic logical relationships among factors through ISM's hierarchical structure model.

Maslow's hierarchy of needs and the DEMATEL-ISM model have been widely utilized by scholars to analyze the interaction mechanisms among various influencing factors. However, there has been insufficient research applying these complex system evaluation methods to furniture design. The primary contribution of this study lies in introducing a novel hybrid theory that offers a new research approach to furniture design. By investigating the current demands of users for outdoor furniture, the study proposes precise design cases, aiming to enhance the development of the Chinese furniture market.

EXPERIMENTAL

Maslow's Hierarchy of Needs

Maslow's hierarchy of needs holds a significant position in modern behavioral science. The hierarchy includes five categories, starting with physiological needs at the base, moving upward to safety needs, social needs, esteem (or ego) needs, and finally, self-actualization needs (Desmet and Fokkinga 2020). These five levels can be further grouped into three dimensions: basic needs, advanced needs, and challenging needs (Zheng *et al.* 2022). An optimized version of Maslow's hierarchy, as illustrated in Fig. 1, suggests that higher-level needs are not addressed until the lower-level needs are satisfied (Thielke *et al.* 2012). Therefore, accurately reflecting user needs in furniture design can significantly enhance the precision of design evaluations, as design decision-making is crucial to the product development process (Fu *et al.* 2024; Liu *et al.* 2024). According to the optimized furniture design demand level, the research team held a meeting with five senior experts with five years of experience in the MACIO design department. MACIO is a large company specializing in the design and manufacture of customized solid wood furniture. In the exchange talks of the conference, it was found that users' preferences are obviously inclined to those wooden dining tables that integrate curved surfaces, versatility, and unique texture in view of the mainstream furniture dining table style trends in the current market. Based on the results of the meeting, the research team carefully sorted out and integrated the collected user needs to form a clear list of needs, as shown in Table 1. This approach laid a foundation for design innovation. On this basis, the theory of DEMATEL-ISM was combined to prepare for the next stage of research. The flow chart of the experimental process is shown in Fig. 2.

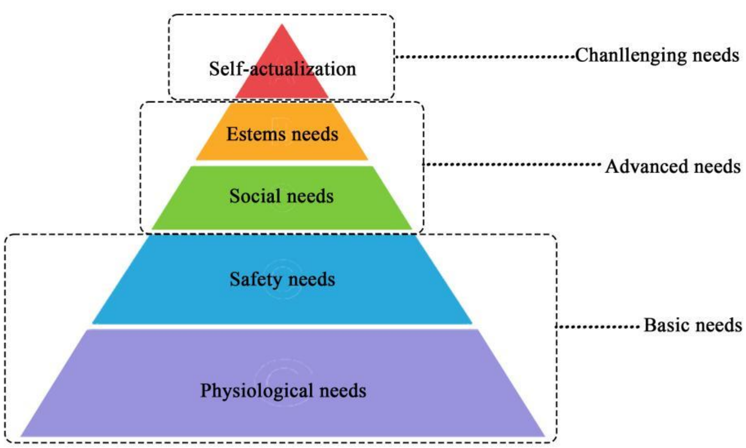

Fig. 1. The division of Maslow's hierarchy of needs

Table 1. Extraction of Maslow's Hierarchy of Needs Factors for Dining Table Designs

Challenging needs	Eco-friendly (A1)	Attractive force (A2)	Cultural fusion (A3)	Value of collection (A4)	Promoting family emotions (A5)
Advanced needs	Beautiful shape (A6)	Harmonization of proportions (A7)	Modularization (A8)	Comfortably (A9)	
Basic needs	Durability (A10)	Moderately priced (A11)	Security (A12)	Easy to clean (A13)	Multi-person use (A14)

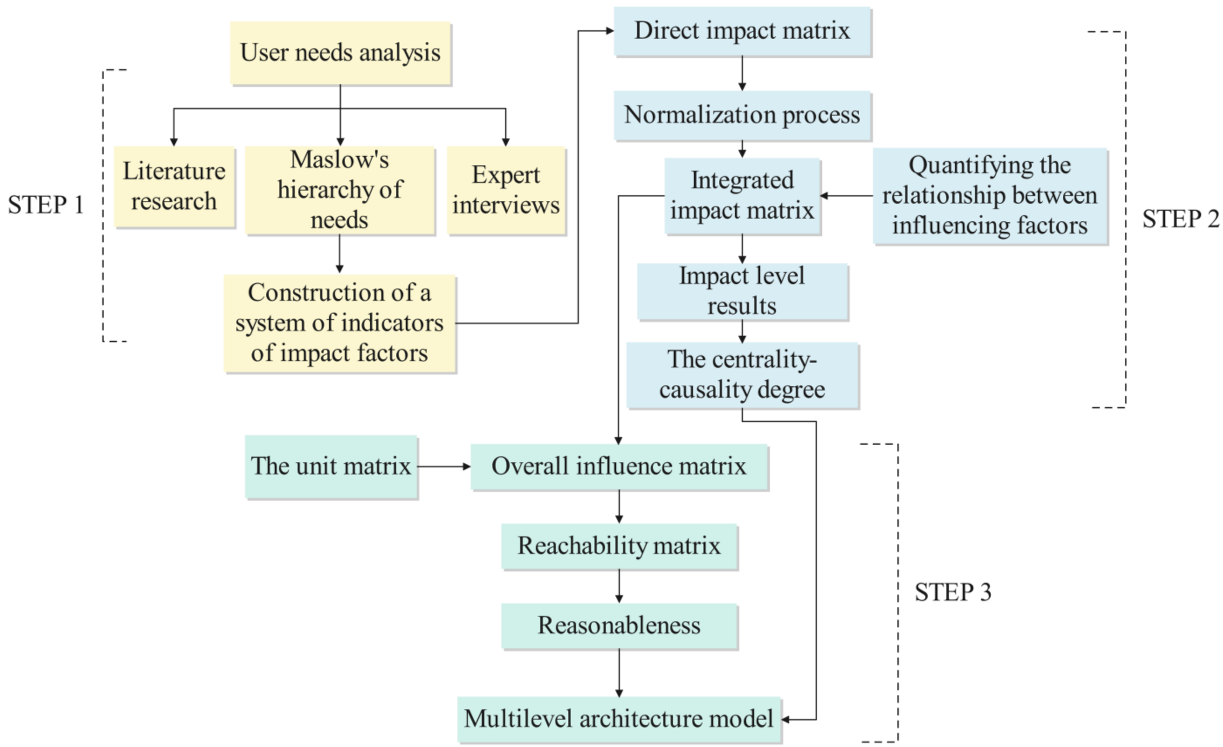

Fig. 2. Dining Table DEMATEL-ISM experimental design flow chart

Directly Affects Matrix Acquisition

The DEMATEL method is designed for analyzing factors within complex systems (Sun *et al.* 2023). It utilizes graph theory and matrix tools to convert differences in the impact of design elements into a weighted directed graph analysis.

Table 2. Initial Impact Matrix A

	Work industries	Expert attributes	Expert working time
Mr. Luo	Whole furniture-Custom wardrobe	Furniture industry practitioners	3
Mr. Li	Whole furniture-Sofa customization		5
Mrs. Ji	Whole furniture-Cabinet customization		3
Mr. Luo	Full-time industrial designer		4
Dr. Li	Professor of Design	Related professional professors	7
Dr.LI			5
Dr. Zhang			10
Mr. Ge	Press and publication practitioners	Consumer	
Mrs. Chen	Railway Traffic Ticket Officer		
Mr. Wu	Wholesale and retail service		
Mr. Zhou	Courier service personnel		
Mr. Wu	Bank clerk		
Mrs. Chen	Pupil	Design professional master graduate student	3
Mr. Jiang			
Mrs. Wei			

Experts rate the relationships between influencing factors to construct a matrix, allowing for the calculation of causality, centrality, and weights to identify fundamental influencing factors in a multi-factor system. The integrated impact matrix obtained through DEMATEL was used to prioritize factors at each level. Based on the key elements identified through Maslow's hierarchy of needs analysis, the DEMATEL method was used to determine the causal relationships among these factors. The elements of DEMATEL are often referred to as "variables," since they reflect multiple characteristics or components of the complex system or issue being investigated (Teymourifar and Trindade 2023). To ensure objectivity during the experimental process, 15 experts were invited to participate in an offline meeting. Table 2 shows the theoretical basis and practical experience of these 15 experts, which can effectively promote the efficient operation of the experimental process.

During the meeting, pairwise comparisons of different factors were conducted, and a consensus was reached on the final scoring results. The formula for the direct influence matrix is provided in Eq. 1.

$$A = \begin{bmatrix} 0 & x_{12} & \cdots\cdots & x_{1n} \\ x_{21} & 0 & \cdots\cdots & x_{2n} \\ \cdots\cdots & \cdots\cdots & \cdots\cdots & \cdots\cdots \\ x_{n1} & x_{n2} & \cdots\cdots & 0 \end{bmatrix} \quad (1)$$

The scoring standard ranged from 0 to 4 points, where 0 indicates no influence, 1 indicates weak influence, 2 indicates moderate influence, 3 indicates strong influence, and 4 indicates very strong influence. The resulting direct influence matrix A is summarized in Table 3.

Table 3. Initial Impact Matrix A

A	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14
A1	0	2	0	1	0	2	1	0	0	0	2	0	0	0
A2	1	0	1	3	3	4	4	0	1	2	0	0	0	0
A3	0	0	0	3	1	0	0	0	0	0	1	0	0	0
A4	1	3	2	0	0	3	3	0	0	0	1	0	0	0
A5	0	0	0	0	0	0	0	0	1	0	0	0	0	4
A6	0	3	1	2	1	0	2	0	0	0	1	0	0	0
A7	0	1	0	0	0	0	0	0	2	0	0	0	0	0
A8	0	0	0	0	0	2	2	0	1	1	1	2	1	2
A9	0	1	0	0	1	1	1	1	0	2	1	0	0	1
A10	0	1	0	0	1	0	0	0	1	0	1	1	0	0
A11	0	1	0	0	0	2	2	0	2	2	0	0	0	0
A12	0	0	0	0	0	0	0	1	0	1	1	0	0	1
A13	0	0	0	0	0	0	1	1	0	0	0	0	0	0
A14	0	0	0	0	3	0	1	2	1	1	1	1	0	0

Based on the results of the initial influence matrix, normalization of the matrix was required. This process involves standardizing the matrix, followed by calculating the maximum sum of rows and columns in the matrix A using Eq. 2. This calculation yields the normalized direct influence matrix [$X = (x_{ij})\ m \times n$].

Table 4. Integrated Impact Matrix T

T	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
T1	0.0143	0.1689	0.0289	0.103	0.0434	0.1747	0.1403	0.0036	0.0422	0.0367	0.1280	0.0029	0.0002	0.0119
T2	0.0711	0.1238	0.0986	0.2277	0.2206	0.2939	0.3241	0.0128	0.122	0.1414	0.0582	0.0117	0.0007	0.0548
T3	0.0115	0.0444	0.0231	0.1741	0.0677	0.0467	0.0519	0.0028	0.0205	0.0152	0.0696	0.0019	0.0002	0.0157
A4	0.0701	0.242	0.1403	0.0897	0.0665	0.2436	0.2665	0.0051	0.0574	0.0426	0.0916	0.0037	0.0003	0.0178
T5	0.0007	0.0101	0.0015	0.0031	0.0435	0.0119	0.0251	0.0288	0.0751	0.0255	0.0206	0.0164	0.0015	0.2275
T6	0.0201	0.2186	0.0858	0.1634	0.1049	0.0855	0.2000	0.0055	0.0500	0.0384	0.0789	0.0040	0.0003	0.0255
T7	0.0044	0.0688	0.0065	0.0148	0.0217	0.0254	0.0285	0.0075	0.1164	0.0219	0.0113	0.0026	0.0004	0.0116
T8	0.0039	0.0488	0.0123	0.0243	0.0459	0.1369	0.1608	0.0279	0.0968	0.0917	0.0867	0.1198	0.0541	0.1293
T9	0.0062	0.0918	0.0126	0.0267	0.0954	0.0943	0.1084	0.0648	0.0445	0.1366	0.0786	0.0184	0.0034	0.0828
T10	0.0046	0.0708	0.0069	0.0156	0.0748	0.0297	0.0338	0.0094	0.0739	0.0269	0.0659	0.0563	0.0005	0.0236
T11	0.0075	0.1065	0.0170	0.0352	0.0428	0.1455	0.1613	0.0099	0.1417	0.1363	0.0278	0.0092	0.0005	0.0180
T12	0.0009	0.0132	0.0021	0.0044	0.0182	0.0182	0.0236	0.0615	0.0215	0.0706	0.0662	0.0136	0.0032	0.0648
T13	0.0004	0.0062	0.0010	0.0021	0.0036	0.0085	0.0626	0.0545	0.0112	0.0060	0.0052	0.0064	0.0029	0.0074
T14	0.0017	0.0252	0.0039	0.0081	0.1829	0.0328	0.0922	0.1208	0.0956	0.0870	0.0782	0.0731	0.0064	0.0601

$$X = \frac{A}{\max\left[\max_{1\le j\le n}\sum_{j}^{n} A_{ij}, \max_{1\le j\le m}\sum_{j}^{m} A_{ij}\right]} \tag{2}$$

Calculation of the Integrated Impact Matrix

To establish the total influence matrix T, the direct influence matrix is squared, which causes all values within the matrix to approach zero, representing the accumulation of indirect influence factors. According to Eq. 3, the standardized influence matrix X is transformed into the total influence matrix T [[T = (t ij) m × n], as shown in Table 4.

$$T = X(1-X)^{-1} \tag{3}$$

Calculating the Degree of Influence (*D*i), the Degree of Being Influenced (*C*i), the Degree of Centrality (*M*i), and the Degree of Cause (*R*i)

The influence D_i was calculated according to Eq. 4. It refers to the sum of each row in matrix T, indicating the comprehensive influence value of each row element on all other elements.

$$D_i = \sum_{j=1}^{n} t_{ij} (i = 1,2,3\ldots\ldots \text{n}) \tag{4}$$

The affected degree C_i was calculated according to Eq. 5. It refers to the sum of each column in matrix T, indicating the comprehensive influence value of each column element on all other elements.

$$C_i = \sum_{j=1}^{n} t_{ij} (i = 1,2,3\ldots\ldots \text{n}) \tag{5}$$

The centrality M_i was calculated according to Eq. 6. It represents the position and the role of a factor in the evaluation system, and is defined as the sum of its influence degree and affected degree.

$$M_i = D_i + C_i \tag{6}$$

The R_i was calculated according to Eq. 7. It is obtained by subtracting the affected degree from the influence degree.

$$R_i = D_i - C_i \tag{7}$$

The weight value of each influencing factor was calculated according to Eq. 8.

$$w_k = \sqrt{(M_i)^2 + (R_i)^2} / \sum_{i=1}^{n} \sqrt{(M_i)^2 + (R_i)^2} \tag{8}$$

The results of the calculations are summarized in Table 5 and are illustrated in Fig. 3, which shows the centrality-causality degree distribution.

Table 5. The Degree of Influence (D_i), the Degree of Being Influenced (C_i), the Degree of Centrality (M_i), and the Degree of Cause (R_i)

	D_i	C_i	M_i	Rank	R_i	Rank	Weight	Factor Attribute
A1	0.8990	0.2174	1.1165	11	0.6816	1	0.0501	cause factor
A2	1.7615	1.2392	3.0007	1	0.5223	3	0.1347	cause factor
A3	0.5453	0.4406	0.9859	12	0.1048	6	0.0443	cause factor
A4	1.3369	0.8922	2.2291	3	0.4447	4	0.1001	cause factor
A5	0.4914	1.0318	1.5231	8	-0.5404	13	0.0684	result factor
A6	1.0809	1.3474	2.4283	2	-0.2665	11	0.1089	result factor
A7	0.3416	1.6791	2.0207	4	-1.3375	14	0.0907	result factor
A8	1.0389	0.4150	1.4539	9	0.6239	2	0.0653	cause factor
A9	0.8646	0.9687	1.8332	5	-0.1041	10	0.0823	result factor
A10	0.4926	0.8766	1.3691	10	-0.3840	12	0.0615	result factor
A11	0.8590	0.8666	1.7256	6	-0.0076	9	0.0775	result factor
A12	0.3820	0.3399	0.7219	13	0.0422	8	0.0324	cause factor
A13	0.1779	0.0745	0.2524	14	0.1035	7	0.0113	cause factor
A14	0.8680	0.7508	1.6188	7	0.1172	5	0.0727	cause factor

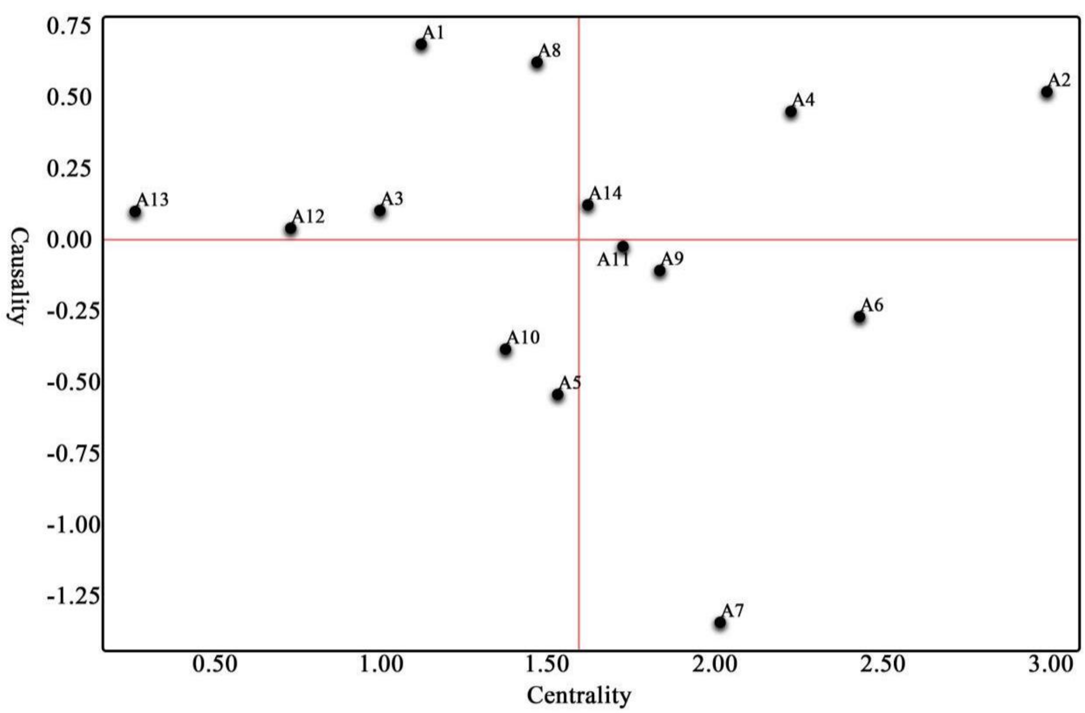

Fig. 3. The centrality-causality degree distribution

Based on the calculation results, a table and a centrality-causality distribution chart were drawn. The chart shows that the weight ranking was A2 > A6 > A4 > A7 > A11 > A14 > A5 > A8 > A10 > A1 > A3 > A12 > A13. Among them, the needs of A2 and A4 belonged to the highest level in the hierarchy, which also indicates that in the furniture user preference system, the high value-added demand at the spiritual level dominated. This requires designers to pay close attention to how to enhance the attractiveness and potential collection value of products in table design to meet the growing spiritual pursuit of users. A11 and A14 are the basic needs in the optimization level. These are the basic elements that users need to consider. In the design, the price of the dining table needs to be considered first, and it also needs to meet the user's options for serving multiple people. Therefore, this is also a factor to be considered. A11 and A14 are classified as basic demand levels, highlighting the practical and functional requirements of the dining table as the core furniture for family and social occasions. These basic elements are not only the basis of user decision-making, but also the key points that must be prioritized in the early stage of design, such as the price-performance ratio of the dining table and the number of people accommodated, which are directly related to the market competitiveness of the product and user satisfaction.

The causality factors are eco-friendly (A1), modularization (A8), attractive force (A2), value of collection (A4), and multi-person use (A14), suggesting that these five factors have a greater influence on other factors and are less affected by other factors. Environmental protection is a major issue in Chinese society. In the process of product design, production and service, priority should be given to ensuring that products meet environmental standards and reduce environmental impact. The modular design in furniture has significant advantages in improving product flexibility and reducing maintenance costs. The use of modular design can effectively promote the collaborative work between the various elements within the system and improve the overall performance. At the same time, modular design is less restricted by other factors in the same category of furniture design, which provides more freedom and flexibility for enterprises in the process of product innovation and upgrading. Novel design can stimulate consumers' attention and purchase desire. In furniture design, attention should be paid to enhancing the attractiveness of products, including appearance design, functional innovation, user experience, and so on, in order to meet the diverse needs of consumers. Collection value is a unique attribute of furniture products, which endows products with cultural, historical, or emotional significance beyond practical value. Products with collection value can attract the attention and pursuit of specific groups, forming a unique market positioning and competitive advantage. At the same time, the collection value is less constrained by other factors, as it is usually related to factors such as scarcity and uniqueness of the product. Multiple users are mainly reflected in the social attributes and sharing value of furniture. A product that can support shared use by multiple people can enhance interaction and co-operation among users, and improve the use value and user satisfaction of the product. At the same time, multiple users also promote the sharing and dissemination of information, which helps to expand the product's market influence and user base. The role and impact of these factors should be fully considered in the process of system design, product development, and service provision, so as to achieve the overall optimisation and sustainable development of the system.

ISM Modeling of Multi-Layer Recursive Order Structures

The Interpretive Structural Modeling (ISM) method analyzes the internal logical structure of complex systems through adjacency matrices and graphical models, constructing a multi-layer hierarchical structure from the bottom up, but it cannot determine the importance of influencing factors within each layer (Xiahou *et al.* 2022).

The calculation formula for the overall influence matrix is given in Eq. 9, where **T** is the comprehensive influence matrix, and **I** is the identity matrix.

$$\mathbf{H} = \mathbf{T} + \mathbf{I} \tag{9}$$

In the overall influence matrix **H**, h_{ij} is set to 0 if it is less than the threshold λ, and to 1 otherwise, to compute the reachability matrix **K**. The calculation formula is shown as Eq. 10. The threshold λ is determined by the mean and standard deviation of the comprehensive influence matrix. The calculation formula is shown as Eq. 11.

$$K = \begin{cases} 1、 h_{ij} \geq \lambda (i, j = 1,2,3\ldots\ldots, \ n) \\ 0、 h_{ij} < \lambda (i, j = 1,2,3\ldots\ldots, \ n) \end{cases} \tag{10}$$

$$\lambda = \overline{X} + \sigma \tag{11}$$

Multiple values were analyzed and interpreted. The mean of the comprehensive influence matrix was 0.0568, and the standard deviation was 0.0638. Using these values, the threshold value was calculated to be 0.1206. The size of the threshold directly affects the composition of the reachability matrix and the division of the system structure (Li *et al.* 2023). Based on Eq. 9, the reachability matrix of the influence factors can be calculated, as shown in Table 6.

Table 6. The Reachability Matrix K

K	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
K1	1	1	0	0	0	1	1	0	0	0	1	0	0	0
K2	0	1	0	1	1	1	1	0	1	1	0	0	0	0
K3	0	0	1	1	0	0	0	0	0	0	0	0	0	0
K4	0	1	1	1	0	1	1	0	0	0	0	0	0	0
K5	0	0	0	0	1	0	0	0	0	0	0	0	0	1
K6	0	1	0	1	0	1	1	0	0	0	0	0	0	0
K7	0	0	0	0	0	0	1	0	0	0	0	0	0	0
K8	0	0	0	0	0	1	1	1	0	0	0	0	0	1
K9	0	0	0	0	0	0	0	0	1	1	0	0	0	0
K10	0	0	0	0	0	0	0	0	0	1	0	0	0	0
K11	0	0	0	0	0	1	1	0	1	1	1	0	0	0
K12	0	0	0	0	0	0	0	0	0	0	0	1	0	0
K13	0	0	0	0	0	0	0	0	0	0	0	0	1	0
K14	0	0	0	0	1	0	0	1	0	0	0	0	0	1

Hierarchy of Influencing Factors

Based on the calculation results of the reachability matrix **K**, the factors corresponding to the columns with values of 1 in each row of the reachability set R_i indicate the set of all factors that can be reached starting from that factor. The factors corresponding to the rows with values of 1 in each column of the antecedent set S indicate the set of all factors that can reach that factor. Let the intersection of the reachability set R_i and the antecedent set S_i be C. When the elements in the reachability set R_i are equal to the elements in its intersection with the antecedent set S_i, it constitutes the first-level factors of the multi-level hierarchical structure model. The calculation formula is shown in Eq. 12.

$$\begin{cases} R_i = \{K \mid K_{ij} = 1\} \\ S_i = \{K \mid K_{ji} = 1\} \end{cases}$$
$$C = R_i \cap S_i \tag{12}$$

According to the ISM result priority rule, hierarchical division was performed. When a_i satisfies $R(a_i) = R(a_i) \cap S(a_i)$, it indicates that a_i is the highest-level factor. The corresponding row and column of factor a_i are removed from the reachability matrix **K**, and the reachability set, antecedent set, and intersection are recalculated. This process is continued to find the next level until all factors are divided, forming the final factor hierarchy. This results in a multi-level hierarchical structure model for improving the posture products for school-age children. By integrating the ranking results of causality and centrality, a multi-level ISM model diagram (Fig. 4) is drawn.

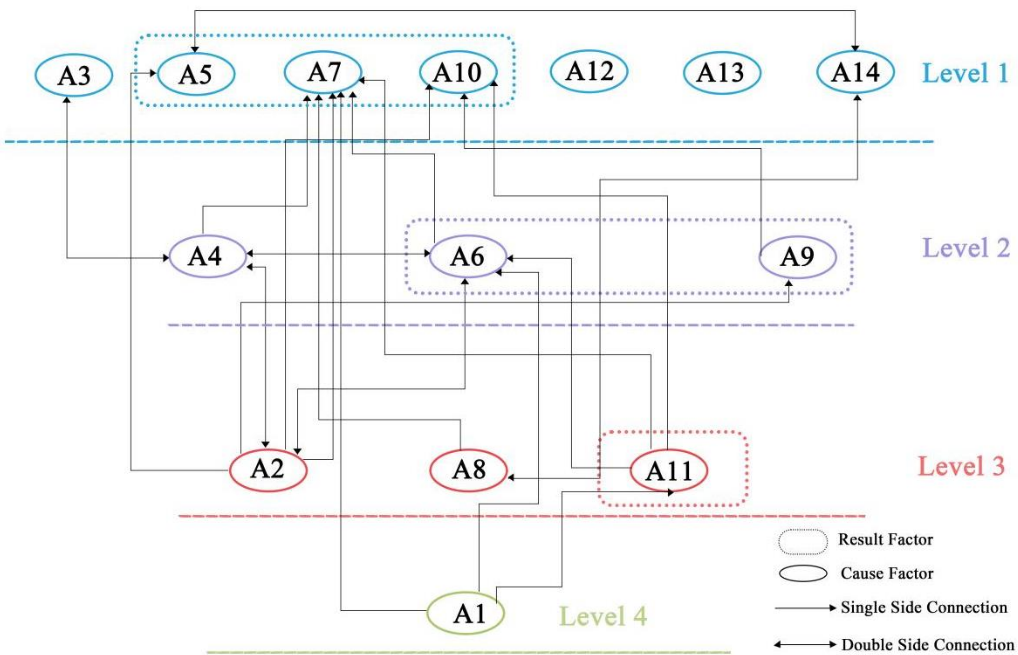

Fig. 4. Comprehensive DEMATEL-ISM influence model path analysis results

Based on the hierarchical decomposition structure in Fig. 4, the complex logical relationships between the factors in the system can be delineated. The six pairs of bidirectional arrows shown in the figure—(A3, A4), (A5, A14), (A4, A6), (A2, A6), (A8, A14), and (A4, A2)—indicate strong mutual influences among these key factors. During the design process, it is crucial to comprehensively consider the possible chain reactions caused by the alteration of one element on another and to implement an integrated research strategy. The bidirectional arrows (A5), (A7), (A10), (A12), (A13), and (A14) are located at the top level (Level 1). These factors are direct elements in the design process and are associated with the basic levels of Maslow's hierarchy of needs, requiring the design to ensure practicality and applicability. Meanwhile, (A4), (A6), and (A9) are situated at the second level (Level 2) as secondary direct factors. It is important to note that the aesthetic element, which is on two key connection lines, is of high importance, second only to the proportion and size in the upper level. Market research on new trends and aesthetic characteristics of dining tables is necessary. The bidirectional arrows (A2), (A8), and (A11) are at the third level (Level 3), and these factors should be considered when refining design details. Finally, (A1) is at the bottom level (Level 4), serving as the starting point for ISM hierarchical decomposition and the most fundamental element. The design team's research system needs to focus on the conservation of biological resources. Combining the results of DEMATEL, the elements in (Level 4) and (Level 3) are classified into the same influence level. These elements are essential in the design, significantly enhancing the overall user satisfaction and emotional experience. Elements in (Level 2) are based on meeting daily dining needs and conveying quality of life and cultural connotation. (Level 1) represents the underlying logic of dining table design and responds to China's green development strategy. According to the path analysis results of the DEMATEL-ISM influence model, dining table design should be guided by ecological friendliness, meeting basic living needs while also aligning with the aesthetic preferences of contemporary Chinese people, achieving a harmonious unity of functionality and aesthetics.

RESULTS AND DISCUSSION

Through the DEMATEL-ISM theory, the complex relationships among the elements in dining table design were divided into a four-level structure, with arrows indicating the logical relationships between each element. Based on the analysis results, the design team began the experimental phase of the case study, conducting an in-depth field study at a MACIO company offline store. This investigation provided insights into the actual living conditions and family structures of contemporary Chinese households. The aim was to ensure that the design scheme aligns with cutting-edge technological trends while precisely meeting users' practical needs and expectations. In Fig. 5, this study proposed three table design schemes to match the attribute preferences of different user groups. The design focuses on practicality, comfort, and personalized expression.

Fig. 5. Different oriented dining table design scheme

The application of Maslow's hierarchy of needs theory in home design can identify the key elements in dining table design. The DEMATEL-ISM method reveals the interrelationships between various factors and the complex element system, aiding designers in comprehensively understanding and taking effective measures during dining table development. In discussing the feasibility of this research system, the design team decided to combine the System Usability Scale (SUS) to evaluate the current design scheme. This approach not only scientifically quantifies the user experience but also facilitates effective communication among stakeholders (Mujinga *et al.* 2018). By using a set of standardized questionnaire questions, the product's perceived usability is quantitatively assessed. Seven design graduate students and professors were invited to score the evaluation. The higher the SUS score, the better the product's usability and a system scoring above 85 is considered to have good usability. The SUS scale can quickly capture the core feedback of the user 's overall experience of the target product in a limited time. The research results shown in Fig. 6 clearly reveal the positive effects of the first set of design cases in improving the user experience through statistical analysis, indicating its ability to bring more pleasant and efficient use experience to users.

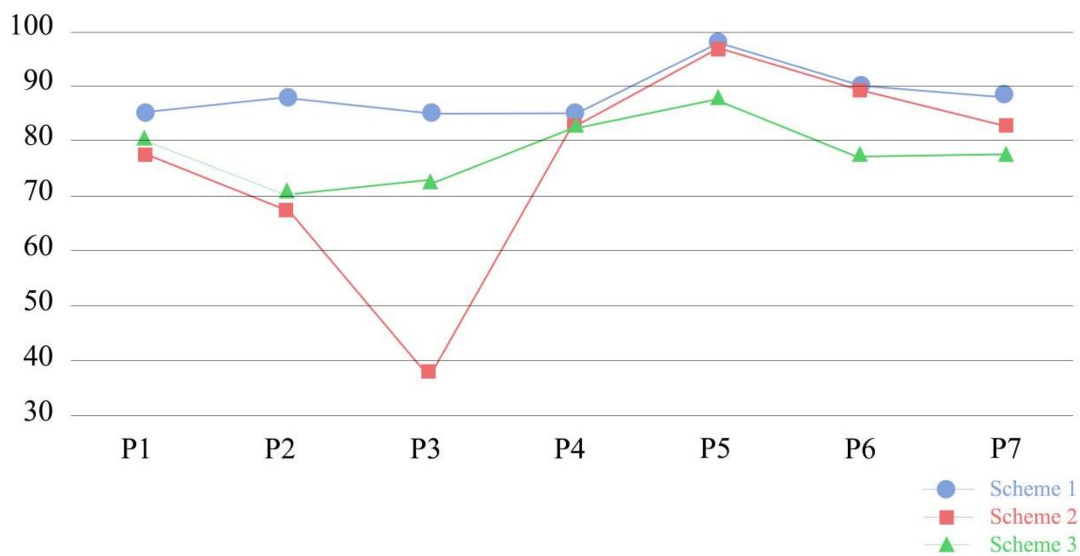

Fig. 6. Usability scale evaluation results of three schemes

Fig. 7. Design solutions for dining tables that meet user satisfaction

The design scheme presented in Fig. 7 focuses on the concept of eco-friendly design and multi-person sharing. This scheme constructs a furniture design that not only meets the basic functional requirements, but it also highly conforms to the principle of sustainable development. Eco-design emphasizes the whole life cycle of the product, ranging from the extraction of raw materials through manufacturing, distribution, and use to final disposal (Yang and Vezzoli 2024). In the dining table design, using recyclable plastic as the primary material for dining chairs is an innovative resource recycling strategy. Discarded plastic can be physically processed, such as through stretching and compression molding, to form the chair cushions from recycled plastic pellets (Pandey *et al.* 2023). Oak was selected as the key material for the dining chair structure due to its hardness, density, compressive strength, bending resistance, and high impact resistance, providing a stable structural foundation for the chair (Uzcategui et al. 2020). Additionally, the unique texture of oak enhances the artistic value of the furniture and meets modern aesthetic demands for the integration of natural elements with human-centered design. Regarding space optimization, according to the "China Population Census Yearbook-2020," the average living area per household member in China is 47.16 square meters. The dining chairs incorporate foldable and extendable mechanisms to maximize the use of limited space resources. By allowing flexible transformation of the chairs (such as extending and expanding during peak usage times and folding and storing during off-peak times), the design effectively reduces the floor space occupied by furniture when not in use, promoting spatial fluidity and multifunctionality in the living environment.

CONCLUSIONS

1. This study integrates Maslow's hierarchy of needs theory and DEMATEL-ISM theory to propose a theoretical system for dining table design. Maslow's hierarchy of needs theory is used to identify the design needs of contemporary users for dining tables, while DEMATEL-ISM theory clarifies the hierarchical relationships and logical structures among various elements. Finally, a design case is presented to validate the feasibility of this theoretical system.
2. Based on DEMATEL, the influence degree, centrality, and causality of each influencing factor in dining table design can be calculated. The results show that attractive force (Mi:3.0007), beautiful shape (Mi:2.4283), value of collection (Mi:2.2291), harmonization of proportions (Mi:2.0207), and comfortably (Mi:1.8332) are the top five centrality factors, having a significant impact on the entire evaluation system. Factors: eco-friendly (Ri:0.6816), modularization (Ri:0.6239), attractive force (Ri:0.5223), value of collection (Ri:0.4447), and multi-person use (Ri:0.1172) greatly influence other factors and are less affected by others. Interpretive Structural Modeling is used to identify the multi-level relationships among the factors and divide them into four levels, with unidirectional and bidirectional arrows reflecting the relationships among elements, ultimately leading to a design approach dominated by eco-friendly (A1).
3. To verify that the DEMATEL-ISM evaluation theoretical system meets user needs, it is combined with the System Usability Scale (SUS) for further validation. Among the three schemes, the first scheme is more in line with the user's expectations. The needs of modern users for dining tables have far exceeded the scope of basic functionality. Users expect dining tables to incorporate emotional resonance and visual aesthetics. China's table market has been able to meet the most basic needs of users, users are keen to apply environmentally friendly materials in furniture, which also shows that China's furniture market is concerned about ecological issues. There are still some deficiencies in this study, and other methods will be considered in the follow-up study to obtain more objective user needs and expand the sample size.

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REFERENCES CITED

Bumgardner, M. S., and Nicholls, D. L. (2020). "Sustainable practices in furniture design: A literature study on customization, biomimicry, competitiveness, and product communication," *Forests* 11(12), article 1277. DOI: 10.3390/f11121277

Chen, J. K. (2021). "Improved DEMATEL-ISM integration approach for complex systems," *Plos One* 16(7), article e0254694. DOI: 10.1371/journal.pone.0254694

Dar, S. A., and Sakthivel, P. (2022). "Maslow/s hierarchy of needs is still relevant in the 21st century," *Journal of Learning and Educational Policy* 2(5), 1-9. DOI: 10.55529/jlep.23.1.9

Desmet, P., and Fokkinga, S. (2020). "Beyond Maslow's pyramid: Introducing a typology of thirteen fundamental needs for human-centered design," *Multimodal Technologies and Interaction* 4(3), article 38. DOI: 10.3390/mti4030038

Fu, L., Lei, Y., Zhu, L., Yan, Y., and Lv, J. (2024). "Integrating Kansei engineering with hesitant fuzzy quality function deployment for rosewood furniture design," *BioResources* 19(3), 6403-6426. DOI: 10.15376/biores.19.3.6403-6426

Fu, L., Wang N., Zhu K., and Shi, C. (2022). "Research on the innovative design of Ming-style stool under the perspective of shape grammar," *Mechanical Design* 39(S2), 227-234.

Karasan, A., Ilbahar, E., Cebi, S., and Kahraman, C. (2022). "Customer-oriented product design using an integrated neutrosophic AHP & DEMATEL & QFD methodology," *Applied Soft Computing* 118, article 108445. DOI: 10.1016/j.asoc.2022.108445

Koca, G., and Yildirim, S. (2021). "Bibliometric analysis of DEMATEL method," *Decision Making: Applications in Management and Engineering* 4(1), 85-103. DOI: 10.31181/dmame2104085g

Li, H., Sun, Y., Zhang, J., Liu, D., Han, Z., and Li, Y. (2023). "Critical uncertainty analysis of the application of new-generation digital technology in China's construction industry—A study based on the LDA-DEMATEL-ISM improvement model," *Applied Sciences* 14(1), article 57. DOI: 10.3390/app14010057

Li, M., Chen, W., Li, L., and Xu, S. (2024). "Yangxin cloth-pasted modern furniture design under topable semantics and FKANO," *Journal of Forestry Engineering* 9(4), 176-184. DOI: 10.13360/j.issn.2096-1359.202310002

Liu, M., Cheng, H. B., Chen, L. P., Liao, A., and Kong, Q. (2024). "Research on harmonious design of chairs based on the Kano model and analytic hierarchy process," *BioResources* 19(3), 5535-5548. DOI: 10.15376/biores.19.3.5535-5548

Liu, X., and Zhang, Z. F. (2013). "Study on the design of outdoor furniture made of recombinant bamboo," *Applied Mechanics and Materials* 397, 907-910. DOI: 10.4028/www.scientific.net/amm.397-400.907

Muhammad Suandi, M. E., Amlus, M. H., Hemdi, A. R., Abd Rahim, S. Z., Ghazali, M. F., and Rahim, N. L. (2022). "A review on sustainability characteristics development for wooden furniture design," *Sustainability* 14(14), article 8748. DOI: 10.3390/su14148748

Mujinga, M., Eloff, M. M., and Kroeze, J. H. (2018). "System usability scale evaluation of online banking services: A South African study," *South African Journal of Science* 114(3-4), 1-8. DOI: 10.17159/sajs.2018/20170065

Pandey, K. P., Jha, U. R., Kushwaha, J., Priyadarsini, M., Meshram, S. U., and Dhoble, A. S. (2023). "Practical ways to recycle plastic: Current status and future aspects," *Journal of Material Cycles and Waste Management* 25(3), 1249-1266. DOI:

10.1007/s10163-023-01611-0
RezaHoseini, A., Ahmadi, E., Saremi, P., and BagherPour, M. (2021). "Implementation of building information modeling (BIM) using hybrid Z-DEMATEL-ISM approach," *Advances in Civil Engineering* 2021(1), article 6686761. DOI: 10.1155/2021/6686761
Rojas, M., Mendez, A., and Watkins-Fassler, K. (2023). "The hierarchy of needs empirical examination of Maslow's theory and lessons for development," *World Development* 165, article 106185. DOI: 10.1016/j.worlddev.2023.106185
Sánchez, S. V., Mahaek, E., and Lekagul, A. (2020). "A framework of design criteria for elderly facilities using Maslow's hierarchy of needs," *NAKHARA (Journal of Environmental Design and Planning)* 18(1), 97-116. DOI: 10.54028/NJ20201897116
Singh, P. K., and Sarkar, P. (2020). "A framework based on fuzzy Delphi and DEMATEL for sustainable product development: A case of Indian automotive industry," *Journal of Cleaner Production* 246, article 118991. DOI: 10.1016/j.jclepro.2019.118991
Sun, R., Geng, X., Zhao, L., Wang, Y., and Guo, R. (2023). "Research on the risk-inducing factors of prefabricated building design change based on improved DEMATEL-ISM," *Buildings* 13(12), article 3036. DOI: 10.3390/buildings13123036
Susanty, A., Tjahjono, B., and Sulistyani, R. E. (2020). "An investigation into circular economy practices in the traditional wooden furniture industry," *Production Planning & Control* 31(16), 1336-1348. DOI: 10.1080/09537287.2019.1707322
Teymourifar, A., and Trindade, M. A. (2023). "Using DEMATEL and ISM for designing green public policies based on the system of systems approach," *Sustainability* 15(14), article 10765. DOI: 10.3390/su151410765
Thielke, S., Harniss, M., Thompson, H., Patel, S., Demiris, G., and Johnson, K. (2012). "Maslow's hierarchy of human needs and the adoption of health-related technologies for older adults," *Ageing International* 37, 470-488. DOI:10.1007/s12126-011-9121-4
Tian, X., Xie, Y., and Zhao, X.(2023). "Research on intelligent furniture product design path based on user needs," *Furniture & Interior Design* 30(11), 15-21. DOI: 10.16771/j.cn43-1247/ts.2023.11.004
Uzcategui, M. C., Seale, R. D., and França, F. N. (2020). "Physical and mechanical properties of clear wood from red oak and white oak," *BioResources* 15(3), 4960-4971. DOI: 10.15376/biores.15.3.4960-4971
Wang, Q., and Chen, Y. (2024). "Applying a Kano-FAST integration approach to design requirements for auditorium chairs," *BioResources* 19(3), 5825-5838. DOI: 10.15376/biores.19.3.5825-5838
Wen, X., and Pashkevych, K. L. (2023). "Analysis of furniture design for growing children based on physiological changes in children," *Art and Design* (3), 57-67. DOI: 10.30857/2617-0272.2023.3.5
Wu, Z., Liu, L., Li, S., and Wang, H. (2020). "Investigating the crucial aspects of developing a healthy dormitory based on Maslow's hierarchy of needs—a case study of Shenzhen," *International Journal of Environmental Research and Public Health* 17(5), article 1565. DOI: 10.3390/ijerph17051565
Xiahou, X., Wu, Y., Duan, T., Lin, P., Li, F., Qu, X., Liu, L., Li, Q., and Liu, J. (2022). "Analyzing critical factors for the smart construction site development: A DEMATEL-ISM based approach," *Buildings* 12(2), article 116. DOI: 10.3390/buildings12020116
Xiong, X., Lu, G., and Lu, D. (2021). "Research on children's customized furniture

design based on group technology," *Applied Sciences* 11(23), article 11371. DOI: 10.3390/app112311371

Yang, D., and Vezzoli, C. (2024). "Designing environmentally sustainable furniture products: Furniture-specific life cycle design guidelines and a toolkit to promote environmental performance," *Sustainability* 16(7), article 2628. DOI: 10.3390/su16072628

Zheng, X., Heath, T., and Guo, S. (2022). "From Maslow to architectural spaces: The assessment of reusing old industrial buildings," *Buildings* 12(11), article 2033. DOI: 10.3390/buildings12112033

Zhu, J., and Niu, J. (2022). "Green material characteristics applied to office desk furniture," *BioResources* 17(2), 2228-2242. DOI: 10.15376/biores.17.2.2228-2242

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