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# Decision Making of Product Design Schemes for Small and Medium-Sized Enterprises Based on Simplified AHP-PUGH

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**Abstract:** To address the contradiction between SMEs' product demand, user needs, and production efficiency in the post-epidemic era, this study aims to shorten SMEs' design cycles and improve their design efficiency, this study takes SMEs as a perspective, considers the weight distribution between enterprise and user interests, and determines the relevant weights and links between users' and enterprises' demands by means of AHP method, and then comes up with relative weights of the product attributes of the two; and then screens and scores and ranks the solutions by using the PUGH The PUGH matrix is used to evaluate and rank solutions, identifying the best option that balances SME and user needs, thereby enhancing design efficiency and decision-making.

**Keywords:** SMEs; design decisions; simplified AHP; PUGH matrix

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## 1. Introduction

With the increase of user consumption awareness and the decrease of product consumption desire in the post epidemic era, the market competition becomes more and more intense, the product iteration is more rapid, and the importance of user needs to product design changes from time to time, in such a background, the traditional experience-based decision-making method based on managers or CEOs is difficult to quickly and accurately insight into user needs, and it is difficult to take into account the diversity of evaluation in program decision-making [1]. criteria. In the face of fierce market competition, more enterprises emphasize rapid testing and feedback, and product iteration and improvement based on the feedback results [2]. Considering the current factors affecting the design of enterprise products, such as limited enterprise resources, dynamic changes in the importance of user and enterprise needs, shorter design cycles, increasingly fast and busy product development schedules, it can be said that weighing the needs of the user and enterprise Achieving better market benefits and making quick decisions on product design solutions are gradually becoming the main factors that determine the success of designers in designing product solutions.

## 2. Existing Enterprise Design Methodology Status Quo

Small and medium-sized enterprises (SMEs) are an important part of China's market economy, iterative and development of SME products in the more limited resources, weighing the importance of the user and the enterprise's needs and rapid design program decision-making is particularly important. Design has an important role in building enterprise competitiveness for SMEs [3], and conceptual design program evaluation and decision-making is an important step to achieve market competitiveness of the product [4]. Currently, the existing design scheme decision-making mainly includes the following studies. For example, some studies have used the KANO model to analyze the elements of user needs for the innovative design of urban short-distance electric bicycles and selected the corresponding conceptual design scheme after identifying the user's key needs. However, they did not make a more objective decision on the design scheme [5]. Based on the APPEALs model, DEMATEL method, and KANO model, a design crowdsourcing-oriented product concept evaluation method was proposed. However, the process is cumbersome, and the computational workload is large, making it unsuitable for small and medium-sized enterprises or teams [6]. Based on the KJ-AHP-QFD model for design research in order to achieve the accurate design elements extracted, so as to solve the design needs of the existing security gate [7]. Evaluation indexes were used to determine the weight coefficient of each index, and the TOPSIS-GRA method was applied to select three preferred office chair design solutions [8]. But there is no comprehensive consideration of the needs of enterprises and users. Currently, there are the following examples of existing user and enterprise stakeholder research based on the concept of value co-creation and participatory design, the comprehensive use of perceptual engineering, NPD co-creative design description, cognitive schema metrics, and other methods and theories on how to achieve brand image design innovation through the joint participation of stakeholders to carry out the research, but because of the high cost of the model does not apply to small and medium-sized enterprises [9]. Other researchers researched and organized women's demand for home fitness equipment and then calculated the weights through the AHP method and CRITIC method, introduced the game theory to synthesize the weights, and finally used the TOPSIS-GRA decision evaluation model to select the final plan, but because of the high threshold of the model, the complexity of calculating the higher cost is not suitable for judging the interests of small and medium-sized enterprises [10]. A study was conducted on how to achieve brand image design innovation through the joint [11]. Using the double game theory, a method was developed to resolve the conflict of interest between electricity sales companies and residential users [11]. This approach aims to optimize multi-subject decisions on the user side and introduces a design method that maximizes the benefits of tariff packages. However, the model's complexity and the extended decision-making process make it impractical for small and medium-sized enterprises.

Most research models and methods aim to enhance enterprise team efficiency, improve final product quality, reduce design costs, and accelerate time to market to meet target user needs. However, many existing design methods and models require significant investment in manpower, time, costs, and personnel budgets. At the same time, the ambiguity in prioritizing user needs and enterprise needs leads to several shortcomings in design planning for SMEs:

1) Some design models and methods fail to conduct qualitative and quantitative analyses of user and business needs, making it difficult to objectively determine their relative importance.
2) Many existing models and methods inadequately balance user and business needs in the selection of design solutions. They often prioritize one aspect while neglecting the other, which negatively impacts product design decisions.
3) Although certain models consider the relationship between user and enterprise needs and integrate multiple methods to mitigate the limitations of a single approach, they still fail to account for the resource constraints of SMEs. These models often require extensive data, have high implementation thresholds, and are difficult for enterprise personnel to adopt. Additionally, their complexity leads to higher operational costs and prolonged decision-making processes.
4) In China’s dynamic business environment, cultural factors influence decision-making, often leading to faster but less precise design decisions. This is largely due to a centralized decision-making style, where CEOs or managers play a

dominant role in design decisions [12]. When the design process is lengthy and complex, this top-down approach can lead to suboptimal outcomes. Furthermore, in a centralized business culture, decision-making heavily relies on managerial experience. As a result, designers often prefer intuitive rather than computational approaches, making data-driven models less applicable to current business and market conditions.

Therefore, it is important to explore models with faster decision-making processes that take into account the needs of users and SMEs, and the AHP-PUGH model is more in line with this need. The design decision of children's companion robots was completed faster with the help of the AHP-PUGH model [13]. The AHP-PUGH model was also used for the conceptual decision-making of product design solutions, providing a good evaluation system for the product concept based on several indicators of user needs [14]. Additionally, the AHP-PUGH model was employed for scoring and selecting design solutions for trouser suits for people with lower limb disabilities, verifying that these solutions better meet the needs of users and SMEs. The scoring and screening of design solutions demonstrated the objectivity and accuracy of the AHP-PUGH model [15]. Based on the above and the characteristics of the AHP-PUGH model, the following conclusions can be drawn:

1) The AHP-PUGH model is objective and accurate, aligning with the existing market environment.
2) It can calculate the weights of each characteristic, allowing the balancing of enterprise and user needs by eliciting these weights.
3) The model involves fewer steps and calculations, with a low threshold and short design process, making it suitable for SMEs' existing design models.

Furthermore, as AHP is suitable for weight calculation without data, has lower costs, is simple to operate, and facilitates faster processes, combined with the PUGH model's advantage in quickly screening design solutions, this study integrates the two methods. By weighting user and enterprise requirements, the model balances both interests, constructs a multi-level judgment matrix, and uses the PUGH model for rapid solution screening. This helps decision-makers accurately identify key requirements and make reasonable product development decisions. The applicability of the model in SMEs' design solution decision-making is further verified through case studies. The design research process is shown in Figure 1.

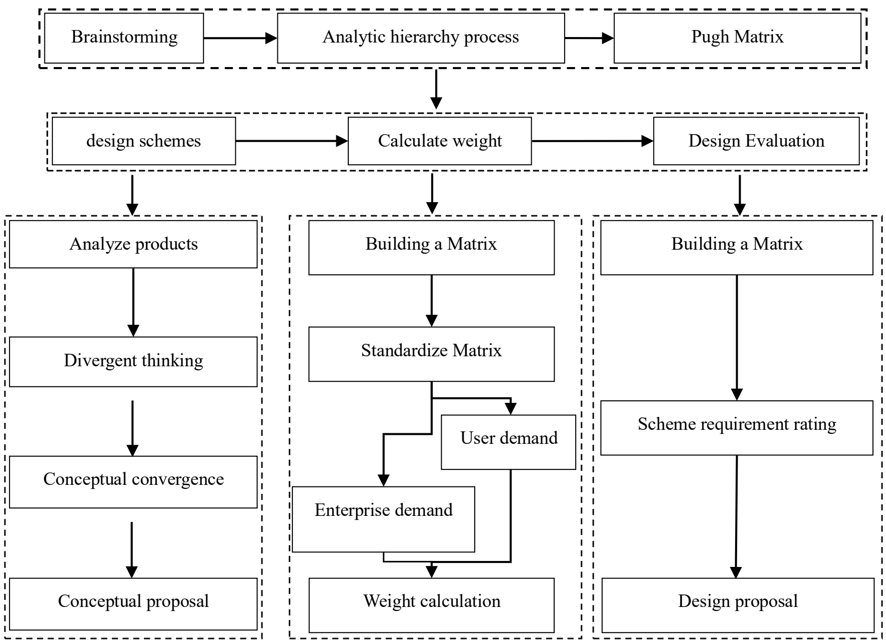


**Figure 1.** Design Decision Process Based on AHP and PUGH Models.

## 3. Product Solution Selection Strategy Modeling

### *3.1. AHP and PUGH Models*

Analytic hierarchy process (AHP) is a multi-objective decision analysis method that combines qualitative and quantitative analysis [16], which is capable of analyzing more complex elements and calculating the weight value of each element [17]. The decision maker quantifies the weights of each criterion and scenario by pairwise comparisons to synthesize the best decision.AHP is capable of handling both qualitative and quantitative information and is widely used in business, government, and the military to improve the quality of decision making [18].The PUGH matrix is a tool used for quantitative decision analysis also known as a conceptual decision matrix, which can be used by a design team to compare among multiple design alternatives and to select [19]. It has also been found that the PUGH matrix cannot be used as a tool to guide the design process because it fails to address the linkages between criteria and the complexity of the design problem [20].

AHP and PUGH matrix have their own advantages and disadvantages when used individually for judging product design solutions, as shown in Table 1. According to the chart, it can be seen that AHP and PUGH can complement each other, thus helping decision makers to find a better product design solution when design time is short or resources are limited, and saving time and cost for subsequent design processes such as re-design and model building.

**Table 1.** Advantages and disadvantages of AHP and PUGH.

| Research methodology | Vantage | Drawbacks |
|---|---|---|
| AHP | By applying a small number of quantitative calculations, the decision-making process can be transformed into a mathematical model, which allows quantification and objectivity in decision-making, and enables the user to face complex evaluations with multiple objectives and criteria in a lighter and more flexible way [21]. | Requires a lot of comparisons and mathematical calculations, and does not allow for rapid program selection and response to market changes. |
| PUGH | The ability to make simple and quick logical decisions, easy to understand and apply, can help decision makers to quickly compare and select options. | It is more subjective and does not allow for an objective understanding of the weights of the attributes. |

Comprehensive use of the advantages of AHP, PUGH model, to establish the SME product design program decision-making model, as shown in Table 2.

**Table 2.** Decision Model for Product Design Scheme of Small and Medium sized Enterprises.

| Specific content | Research methodology | Specific objectives |
|---|---|---|
| Design Solution Acquisition | brainstorming | Access to multiple product design solutions |
| Weighting Calculation | AHP | Determine the weight of each evaluation indicator for users, enterprises |

| | | |
|---|---|---|
| Design Options | PUGH | Rapid evaluation of design options and selection of the best solution |
| Product Program Selection Strategy Outputs | Product Design Solution Selection Process | Provide a clear solution selection process for complex requirements and numerous options |

### *3.2. Acquisition of Design Solutions*

The designers conducted brainstorming to generate a large number of conceptual design solutions for the enterprise products, and selected a number of relatively reasonable design solutions after discussion and screening by the team of designers and members of the expert group.

### *3.3. Calculate the Weight of Each Design Scheme Evaluation Index Based on AHP Method*

Based on the AHP method to calculate the weight of each design scheme evaluation index, that is, the degree of importance of the design scheme evaluation index. The traditional AHP has certain shortcomings in the current rapidly changing market environment, so this study will use the simplified AHP method to shorten the decision-making process and improve the decision-making rate. Simplified AHP has the following characteristics:

1) In order to make the two-by-two comparison more intuitive and to a certain extent reflect the expert's judgment ability, the form of integer ratio is used in the comparison or 0-m is used as a scale.
2) The elements of the judgment matrix in each row are arranged in order rather than by number, so that operations with the nature of keeping the ordering can be applied.
3) When the consistency test is carried out, if the test result shows that does not meet the consistency requirements, it is difficult for the designer to effectively adjust the overall inconsistency.

In order to avoid the simplified problem from becoming complicated again, the analysis results can be regarded as qualified as long as they can be recognized by the decision maker or do not violate the accepted norms [22]. After that, the target layer and criterion layer are constructed, in order to balance the interests between the enterprise and the user demand, this study adopts the weight to quantify and balance the interests of the two, and when the weight of a certain one is larger, the interests of that one should be given priority; therefore, the target layer is the output of the design scheme, and the criterion layer is the user demand and enterprise demand. At the same time, in order to shorten the design decision-making process, the structural model adopted is a three-order model, the first layer is the target layer, i.e., the goal is to quickly, objectively and comprehensively complete the design evaluation, the second layer is the criterion layer, i.e., for the user and enterprise needs, and the third layer is the index layer, i.e., for the product program evaluation index. There are many indicators affecting the product design scheme, and comprehensive consideration of the indicators is more likely to improve the feasibility of the product, so combined with the market research, and the relevant industrial design evaluation standards [23-26], the index system is organized as shown in Figure 2.

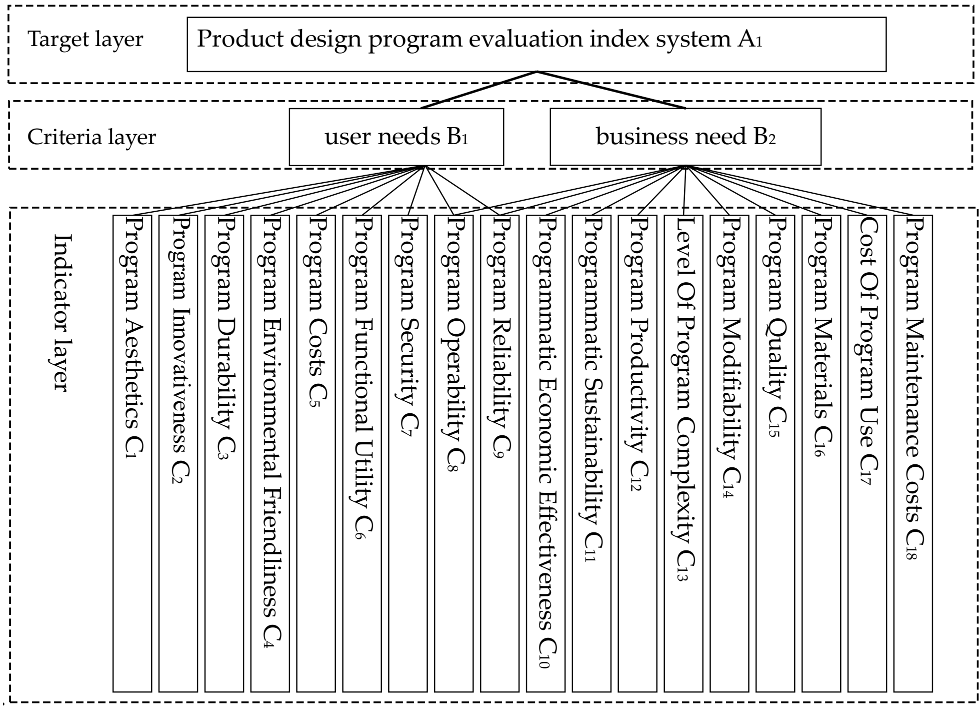


**Figure 2.** Product Design Scheme Decision Index System.

Construct a single-sorting preference graph according to the needs of the problem, calculating the hierarchy of single sorting layer by layer. For the sake of generality, taking the $k+1th$ level left elements $(X_1, X_2, \ldots, X_i)$ and the upper elements $(X_1, X_2, \ldots, X_i)$ relative to a certain element $Y_j$ of the $k$th level as an example, the preference graph is shown in Table 3.

**Table 3.** Single Sort Order Chart.

| $Y_j$ | $X_1$ | $X_2$ | … | $X_i$ | Row Sum | Row Sum Normalization |
|---|---|---|---|---|---|---|
| $X_1$ | 0 | $m-a$ | … | $m-b$ | $\sum X_1$ | $w_1$ |
| $X_2$ | $a$ | 0 | … | $m-c$ | $\sum X_2$ | $w_2$ |
| … | … | … | … | … | … | … |
| $X_i$ | $b$ | $c$ | … | 0 | $\sum X_i$ | $w_i$ |

"0" indicates that each element is not compared with itself; the remaining numbers filled range from 0 to $m$, where $a$, $b$, $c$ are positive integers less than m; the sum of the numbers in the same row, denoted as $\sum X_1$, represents the score of the $i$-th row of the matrix; the normalized values are represented by $w_1$, where the numerical values indicate the degree of superiority of the comparators, with larger values indicating greater superiority. Included among these:

$$\sum X_i = \sum_{j=1}^{1} X_{ij}, w_i = \sum_{j=1}^{1} X_{ij} \sum_{i=1}^{1} \sum_{j=1}^{1} X_{ij}$$

Finally, the total ordering calculation is performed. The purpose of the total ordering is to find out the priority of each element at the bottom level, and all the priority judgment matrices can be found by the recursive concept.

$$W^{K+1} = B_{K+1} B_K \ldots B_2$$

Where $B_K$ is the priority matrix of the elements at level $k$ relative to the attributes at level $k-1$, and $W^{K+1}$is the priority value matrix of the elements at level $k+1$ relative to the top-level objective.

### *3.4. Design Options*

PUGH model is a quantitative decision-making analysis tool, applicable to all stages of evaluation decision-making, can be more objective and systematic evaluation of the design concept program [27,28]. The core of the Brillouin Matrix is to select a benchmark solution according to the judgment criteria, and the rest of the solutions were qualitatively compared with it and the trade-off analysis to get an objective and scientific synthesis score to get a better concept of the product design solution, which allows designers to objectively and systematically judge the optimal design solution among multiple design solutions. In the above case, the PUGH model will introduce the enterprise and user dimensions to evaluate the product attributes.

Create a PUGH decision matrix: List all alternative options and then specify the criteria that have a significant impact on the decision. These evaluation criteria will be listed in the horizontal rows of the PUGH decision matrix, while the alternatives will be listed in the vertical columns. Among the available alternatives, a baseline option is selected based on the evaluation criteria. Afterwards, in the PUGH decision matrix, the benchmark solution is compared with alternative n using m as the evaluation criterion and the relevant values are obtained. The three symbols "+", "0" and "-" are used to represent different values. In the comparison, "+" indicates that the alternative is superior to the baseline solution, "0" indicates that the alternative is comparable to the baseline solution, and "-" indicates that the alternative is inferior to the baseline solution. Based on these symbols, the results of comparing the baseline option with the alternatives are tallied, the composite scores of the alternatives are calculated, and these scores are ranked in descending order to prioritize the alternatives and find the best option. In a two-by-two comparison, not only will the best alternative be found, but excellent choices among the other alternatives will also be identified, which can help to refine and complement future design options. Ensure that the baseline solution has no more than 20 alternatives with the highest combined score, and conduct subsequent scoring and comparison of these alternatives.

Product design solution scoring: for the screened alternatives, create a PUGH decision matrix and select one solution as the reference solution. The scoring level is indicated by a number from 1 to 5, where "very inferior to the reference program" is indicated by 1, "inferior to the reference program" is indicated by 2, "equal to the reference program" is indicated by 3, "superior to the reference program" is indicated by 3, "superior to the reference program" is indicated by 3, and "superior to the reference program" is indicated by 3. "Better than Reference" is denoted by 4, and 'Very Better than Reference' is denoted by 5. Next, the scores of the different alternatives were multiplied by the hierarchical analysis formula to calculate the weights of each sub-evaluation indicator, and these results were weighted and added together to arrive at a composite score for the different alternatives, as shown in the formula below:

$$S_j = \sum_{i=1}^{n} D_{ij} W_i$$

For the comprehensive score of alternative scheme $j$, it is denoted as $S_j$, where $n$ represents the number of subevaluation criteria. The rating score $W_i$ of alternative scheme $j$ in subevaluation criterion $i$, with its overall weight in $D_{ij}$, is represented as the comprehensive weight of I. Summing up the weighted scores of each of the following subevaluation criteria, and ranking based on the total scores of each scheme, leads to the identification of top-ranking product schemes.

### *3.5. Satisfaction Analysis*

If the decision maker is satisfied with the results of the value analysis or it does not violate the public knowledge it is considered reasonable, otherwise re-conceptualize the function or check the reasonableness of the scale.

### *3.6. Product Solution Selection Strategy Output*

Brainstorming design options outputs for enterprise products, and screening by multiple design experts to obtain the remaining options. Using the AHP method, the evaluation criteria are defined and a hierarchy is constructed from both the user and enterprise aspects, and a team of design experts determines the relative importance of different design solutions under each criterion through pairwise comparisons, and a scale is used to complete the comparison of the importance of two criteria with each other. Based on the results of the above pairwise comparisons, the weights of each criterion are calculated, after which the composite score of each product design solution is calculated by combining each design solution with the established criterion weights. Afterwards, using the PUGH model, evaluation criteria such as performance, cost, and reliability are determined, and the design solutions are evaluated based on these criteria. The team of design experts evaluated each design solution against the benchmark solution using the PUGH decision matrix to mark the strengths and weaknesses of each solution under different criteria. The performance of each design option under each criterion is synthesized to produce an overall evaluation of each option, and a satisfaction analysis is performed to determine the final preferred option.

## 4. Example Applications

Take a children's study desk and chair design project of an enterprise in Zhejiang as an example, which is designed by a small and medium-sized enterprise design company. In the product design program decision-making in this field, often only with the boss, design manager, chief designer or technical staff experience to design program decision-making. Because this experience-based decision-making lacks of scientific and if the decision-making problems will lead to more time costs and waste of resources, it is often unable to decide on the optimal product design program, but at the same time, because some of the design process is too cumbersome and will increase the design cycle and resource costs, which will cause pressure and losses to the subsequent re-design, put into the market and other links. Aiming at this problem, the design decision-making based on simplified AHP-PUGH has greatly improved the design efficiency and the success rate of product design decision-making, and the design solutions after the decision-making have been put into the market, which also verifies the scientific nature of the model to a certain extent.

### *4.1. AHP to Determine the Weight Values of Evaluation Indicators*

After brainstorming and selecting several design options, the evaluation of each indicator for the study table designs began. After consultation, the preferred order matrix was obtained as follows:

$$\boldsymbol{A_1} = \begin{bmatrix} 0 & 4 \\ 6 & 0 \end{bmatrix}$$

$$\boldsymbol{B_1} = \begin{bmatrix} 0 & 4 & 5 & 6 & 3 & 4 & 4 & 5 & 4 \\ 6 & 0 & 4 & 5 & 3 & 2 & 2 & 3 & 3 \\ 5 & 6 & 0 & 6 & 3 & 3 & 3 & 4 & 3 \\ 4 & 5 & 4 & 0 & 3 & 3 & 3 & 4 & 4 \\ 7 & 7 & 7 & 7 & 0 & 4 & 5 & 6 & 6 \\ 6 & 8 & 7 & 7 & 6 & 0 & 5 & 5 & 5 \\ 6 & 8 & 7 & 7 & 5 & 5 & 0 & 6 & 5 \\ 5 & 7 & 6 & 6 & 5 & 5 & 4 & 0 & 6 \\ 6 & 7 & 7 & 6 & 4 & 5 & 5 & 6 & 0 \end{bmatrix}$$

$$\boldsymbol{B_2} = \begin{bmatrix} 0 & 4 & 3 & 7 & 5 & 6 & 6 & 5 & 4 & 3 & 6 \\ 6 & 0 & 3 & 7 & 5 & 6 & 7 & 6 & 5 & 3 & 6 \\ 7 & 7 & 0 & 8 & 6 & 6 & 7 & 6 & 5 & 4 & 7 \\ 3 & 3 & 2 & 0 & 3 & 4 & 4 & 3 & 2 & 2 & 4 \\ 5 & 5 & 4 & 7 & 0 & 5 & 5 & 4 & 4 & 3 & 6 \\ 4 & 4 & 4 & 6 & 5 & 0 & 5 & 4 & 4 & 3 & 6 \\ 4 & 3 & 3 & 6 & 5 & 5 & 0 & 4 & 3 & 2 & 4 \\ 5 & 4 & 4 & 7 & 6 & 6 & 6 & 0 & 3 & 3 & 6 \\ 6 & 5 & 5 & 8 & 6 & 6 & 7 & 7 & 0 & 2 & 4 \\ 7 & 7 & 6 & 8 & 7 & 7 & 8 & 7 & 8 & 0 & 7 \\ 4 & 4 & 3 & 6 & 4 & 4 & 6 & 4 & 6 & 3 & 0 \end{bmatrix}$$

Calculate the row sums of the matrices provided above and normalize the resulting vectors. The priority matrix of the second-level elements to the first-level elements is $\boldsymbol{A} = [\mathbf{0.4} \quad \mathbf{0.6}]^{\boldsymbol{T}}$ , and the priority matrix of the third-level elements to the second-level elements is:

$$B = \begin{bmatrix} 0.097 & 0.089 \\ 0.078 & 0.098 \\ 0.092 & 0.115 \\ 0.083 & 0.055 \\ 0.136 & 0.087 \\ 0.136 & 0.082 \\ 0.136 & 0.071 \\ 0.114 & 0.091 \\ 0.128 & 0.102 \\ & 0.131 \\ & 0.080 \end{bmatrix}$$

Then, the weights of the indicators for each study table design option were calculated, as shown in Table 4 below:

**Table 4.** Comprehensive weight of sub evaluation indicators for learning desk design scheme.

| Evaluation indicators and weights under the overall objective | Sub-evaluation indicators and weights | | Combined weights |
|---|---|---|---|
| user needs (0.4) | Program aesthetics | 0.097 | 0.039 |
| | Program innovativeness | 0.078 | 0.031 |
| | Program Durability | 0.092 | 0.037 |
| | Program environmental friendliness | 0.083 | 0.033 |
| | Program costs | 0.136 | 0.054 |
| | Program Functional Utility | 0.136 | 0.054 |
| | Program security | 0.136 | 0.054 |
| | Program operability | 0.114 | 0.046 |
| | Program reliability | 0.128 | 0.051 |
| business need (0.6) | Program operability | 0.089 | 0.053 |
| | Program reliability | 0.098 | 0.059 |
| | Programmatic economic effectiveness | 0.115 | 0.069 |
| | Programmatic sustainability | 0.055 | 0.033 |
| | Program productivity | 0.087 | 0.052 |
| | Level of program complexity | 0.082 | 0.049 |
| | Program modifiability | 0.071 | 0.043 |
| | Program quality | 0.091 | 0.055 |
| | Program materials | 0.102 | 0.061 |
| | Cost of program use | 0.131 | 0.079 |
| | Program maintenance costs | 0.080 | 0.048 |

### *4.2. Selection of Study Table Design Solutions Based on PUGH Decision Matrix*

The expert group members carefully discussed and selected the conceptual design solutions of the study table generated by brainstorming, and finally selected 9 design solutions to construct the PUGH decision matrix used for concept rough screening (Table 5).

**Table 5.** PUGH Decision Matrix for Rough Screening of Learning Desk Design Scheme.

| Evaluation indicators | Study table design program | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** |
| user needs | 0 | - | - | + | 0 | - | 0 | + | 0 |
| business need | 0 | - | 0 | - | + | - | - | + | - |
| Total + | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 2 | 0 |
| Total 0 | 2 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| Total - | 0 | 2 | 1 | 1 | 0 | 2 | 1 | 0 | 1 |
| Net fraction | 0 | -2 | -1 | 0 | 1 | -2 | -1 | 2 | -1 |
| Arrange in order | 3 | 5 | 4 | 3 | 2 | 5 | 4 | 1 | 4 |
| Whether or not to proceed | Yes | No | No | Yes | Yes | No | No | Yes | No |

Using Scenario C as a reference for evaluation, the net scores were ranked from highest to lowest to obtain Scenario A, Scenario D, Scenario E, and Scenario H. Scenarios were entered into the conceptual scoring and are shown in Figure 3.

**(a) A** **(b) D** **(c) E** **(d) H.**

**Figure 3.** Design Proposal for Learning Desk.

In order to better balance the needs of users and enterprises as well as to make the rating more scientific, the design team conducted detailed questionnaire research and in-depth interviews with 10 users who had purchased study desks and 10 technicians from enterprises, obtained 20 valid questionnaires, and then calculated the data of each index of the 4 study desk design solutions and rated them on a scale of 1-5. The PUGH decision matrix is constructed with Program A as the reference standard and the comprehensive score of the four design solutions is calculated (Table 6).According to the comprehensive score, Program H is the best design solution for the study table, and it can be modified and redesigned later to make it closer to the requirements of the users and the enterprise, and to realize the final design solution.

**Table 6.** Comprehensive evaluation of learning desk design concept.

| Evaluation indicators and their weights | | | Options | | | |
|---|---|---|---|---|---|---|
| | | | **A** | **D** | **E** | **H** |
| user needs | Program aesthetics | 0.039 | 0.117 | 0.156 | 0.117 | 0.117 |
| | Program innovativeness | 0.031 | 0.093 | 0.124 | 0.062 | 0.062 |
| | Program Durability | 0.037 | 0.110 | 0.037 | 0.110 | 0.183 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Program environmental friendliness | 0.033 | 0.100 | 0.033 | 0.100 | 0.167 |
| | Program costs | 0.054 | 0.163 | 0.109 | 0.218 | 0.218 |
| | Program Functional Utility | 0.054 | 0.163 | 0.109 | 0.163 | 0.163 |
| | Program security | 0.054 | 0.163 | 0.109 | 0.163 | 0.218 |
| | Program operability | 0.046 | 0.137 | 0.091 | 0.182 | 0.182 |
| | Program reliability | 0.051 | 0.153 | 0.102 | 0.153 | 0.204 |
| business need | Program operability | 0.053 | 0.160 | 0.053 | 0.214 | 0.214 |
| | Program reliability | 0.059 | 0.177 | 0.059 | 0.236 | 0.236 |
| | Programmatic economic effectiveness | 0.069 | 0.206 | 0.206 | 0.206 | 0.275 |
| | Programmatic sustainability | 0.033 | 0.098 | 0.065 | 0.131 | 0.131 |
| | Program productivity | 0.052 | 0.157 | 0.105 | 0.209 | 0.209 |
| | Level of program complexity | 0.049 | 0.147 | 0.049 | 0.196 | 0.196 |
| | Program modifiability | 0.043 | 0.128 | 0.085 | 0.128 | 0.170 |
| | Program quality | 0.055 | 0.164 | 0.109 | 0.164 | 0.164 |
| | Program materials | 0.061 | 0.183 | 0.183 | 0.244 | 0.122 |
| | Cost of program use | 0.079 | 0.236 | 0.157 | 0.314 | 0.236 |
| | Program maintenance costs | 0.048 | 0.144 | 0.096 | 0.192 | 0.144 |
| overall rating | | 1 | 3 | 2.038 | 3.503 | 3.611 |

As shown in Table 6, the four study table design options from the best to the worst: H program, E program, A program, D program. That is, the H scheme can balance the needs of users and enterprises at the same time to meet the interests of both maximization.

### *4.3. Satisfaction Analysis*

The small and medium-sized team adopted a more subjective decision-making approach, relying on qualitative analysis and judgment. They concluded that Option E was preferable for business needs, while Option H better satisfied user requirements. The decision is not thorough and requires a second evaluation by the team or further empirical validation at a higher level. The empirical decision-making steps are not clear and less objective, and when problems arise, it is necessary to carry out more cumbersome decision-making steps or waste more time and cost, which is not only difficult to make scientific decisions but also easy to delay the design progress. Simplified AHP-PUGH model points out that the final study table design concept and the design team based on the empirical decision-making judgment is basically the same conclusion, and quantitative data in the form of more intuitive to the advantages and disadvantages of the program to show, can be clearly done to the advantages and disadvantages of the design program comparison, so that the user and the enterprise's common interests in order to get the balance between the user and the enterprise's needs, and at the same time clear steps to make the At the same time, the steps are also clear so that the decision-making is more rapid and has a strong scientific nature. As a result, the decision maker is satisfied with the analysis, considering it reasonable, scientific, and acceptable. Thus, the H scheme was chosen.The decision maker believes that this method is more suitable for small and medium-sized teams to make design decisions than traditional decision making, and that the model is quick to use and simple to compute, which can shorten the design process to a certain extent. After the decision-making process, the designers improved the H-solution, which was later adopted by the organization and became a sales product.

## 5. Conclusion

This study proposes a simplified AHP-PUGH design solution decision-making model that considers multiple product design solution indicators and balances the needs of enterprises and users. The simplified AHP-PUGH model balances the interests of the two stakeholders, the enterprise and the user, in the decision-making process by introducing their needs for design solutions into the weighting calculation, which not only enhances the scientific nature of decision-making, but also strengthens the accuracy and efficiency of the enterprise's product design and development, and effectively makes up for the shortcomings of the traditional empirical decision-making and bid evaluation methods. This method can deal with decision-making problems in a more simple, scientific and effective way, so it has certain theoretical significance and reference value to promote this method in market practice.

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