



Design Exploration of Combs in Changzhou Based on Analytic Hierarchy Process

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Abstract. Changzhou comb is a national intangible cultural heritage, currently facing problems such as the solidification of product design mode. In order to improve the user's needs and enhance the user experience, this paper uses the analytic hierarchy process to analyze the user's needs, establishes the design elements, and establishes the Changzhou comb index weight determination model from the three aspects of function, appearance and experience. The four variables at the first level are combined with the consumer scoring data to carry out multiple regression, and the qualitative conclusion that consumers are more inclined is drawn, and the improvement plan for the example comb design is proposed.

Keywords: Changzhou Comb · Intangible Cultural Heritage · Analytic Hierarchy Process · Multiple Regression · Product Improvement

1 Introduction

Changzhou combs are known as “the famous palace combs” and “Changzhou combs are the best in the world”, and are very popular among the masses. Their patterns, shapes and other arts are not only the display of local folk art, but also an important embodiment of the creativity of Changzhou folk artists [1]. However, in the face of the current fierce market environment and people's ever-changing living needs, the existing design and production mode of Changzhou Comb has been solidified, and it still relies on the long-term experience of craftsmen to create the shape of the comb, lacking in-depth research on the current market and the public aesthetic investigation.

2 Construction of the Design Element Index Level Model

Analytic Hierarchy Process (AHP) is a hierarchical weighted decision analysis method proposed by American statistician Professor Saaty in his research in the early 1970s [3]. It is a comprehensive multi-criteria decision-making strategy [4], which provides a reasonable and scientific reference for the improvement and design of the scheme. Li Xuerui et al. studied the comprehensive evaluation and ranking of industrial design schemes through grey relational analysis, analytic hierarchy process (AHP) and entropy weight method [2].

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Table 1. Evaluation Matrix Model

Target layer	Criterion layer
A Changzhou comb design scheme optimization B1 appearance factor	B1 appearance factor
	B2 functional factors
	B3 Experience Factors

Table 2. Proportional scaling method.

Scale	Definition
1	Factor i is equally important as factor j
3	Factor i is slightly more important than factor j
5	Factor i is more important than factor j
7	Factor i is more important than factor j
9	Factor i is extremely important compared to factor j
2 4 6 8	Intermediate value of the above comparison degrees
Reciprocal of 1 to 9	Indicates the scale value of factor i compared to factor j The reciprocal of the scale value of factor j compared to factor i

2.1 Construction of Design Element Index Level Model

From the function, appearance, and experience of Changzhou comb, three criteria levels are cut in, as shown in Table 1. Use AHP to calculate the value and proportion of features, and then use the data to determine and quantify design points to reduce the proportion of errors that are only scored by personnel.

2.2 Constructing a Pairwise Comparison Matrix of Evaluation Elements

Determine the set of evaluation elements: According to the analytic hierarchy process, in order to calculate the weights of the design elements of each layer, a matrix is constructed in the form of pairwise comparison, assuming that there are n elements $A = \{a_{ij}, i = 1,2,3; j = 1,2,3\}$ Among them: a_{ij} represents the comparison of the contribution of element B_i and element B_j to the upper-level indicators (for example, a_{12} is the comparison of the importance of appearance element B1 and functional element B2), and all factors in the criterion layer that affect each factor of the previous step, a paired comparison matrix is constructed by the users who purchase Changzhou combs using the pairwise comparison method and the comparison scale of 1 to 9, as shown in Table 2.

Changzhou Comb Design has established a first-level criterion layer according to user needs, which are appearance factor B1, functional factor B2, and experience factor B3. Through the formula, the Changzhou comb was surveyed in the form of a questionnaire, and 20 men and 40 consumers were called to score, and the Defer method was used to calculate multiple rounds to construct a judgment matrix.

After the comparison coefficient is obtained in the pairwise comparison, the arithmetic mean is taken to know that the mean ratio of appearance and function importance is 2.5, the mean ratio of appearance and experience importance is 5.9, and the mean ratio of function and experience importance is 2.1. Take the reciprocal of the corresponding data from the diagonal corner of the table, and enter the result into matrix A to get:

$$A = \begin{bmatrix} 1 & 2.5 & 5.9 \\ 1/2.5 & 1 & 2.1 \\ 1/5.9 & 1/2.1 & 1 \end{bmatrix}. \quad (1)$$

2.3 Weight Vector Calculation

Check the consistency of the matrix to determine whether this method can be applied to determine the three feature weights.

The maximum eigenvalue that can be obtained by calculation is:

$$\lambda = 3.0028. \quad (2)$$

Calculate the consistency index:

$$CI = \frac{\lambda - n}{n - 1} = \frac{3.0028 - n}{n - 1} = 0.0014. \quad (3)$$

After looking up the table, when $n = 3$, the random consistency index: $RI = 0.58$.

$$CR = \frac{CI}{RI} = \frac{0.0014}{0.58} = 0.0024 < 0.1. \quad (4)$$

The comparison matrix A passed the consistency check.

The calculated weight vector (eigenvector) is

$$w = \begin{bmatrix} 0.633 \\ 0.254 \\ 0.112 \end{bmatrix}. \quad (5)$$

Therefore, the weights of appearance, function, and experience are 0.633, 0.254, and 0.112 respectively, that is, when choosing to buy Changzhou combs, appearance is the most important among the three, with a weight of 63.3%. The following sections focus on the following features in the appearance level (Table 3).

Table 3. Hierarchical grading table

Target layer	Criterion layer	Criterion layer
A Changzhou comb design scheme optimization	B ₁ appearance factor	C ₁ pattern
		C ₂ styling
		C ₃ color
		C ₄ shape
	B ₂ functional factor	/
	B ₃ functional factor	/

3 The Influence of Several Characteristics Under the Appearance Level

3.1 Four Kinds of Feature Extraction Under the Appearance Level

In the early stage, through the collection of Changzhou comb styles, 21 representative combs were selected as the research objects, and the four most obvious characteristics were extracted from them, namely whether the pattern is complex, whether the shape has a handle or not, the color depth, and whether the shape is square or not.

3.2 Symbol Naming and Interpretation

Y: Overall score, 40 people scored 21 combs through the Likert scale to obtain the average score.

X1: Whether the pattern is complicated or not, it is the object's preference for the pattern of comb products, the highest level of pattern complexity is recorded as 10, and the pattern is not complicated as 1.

X2: Whether the shape of the comb grate has a handle or not, which is the object's preference for the appearance and shape of the comb grate product. The record with a handle is 10, and the record without a handle is 1.

X3: Color depth, which is the color preference of the survey respondents for comb products, the color depth is recorded as 10, and the light color is recorded as 1.

X4: Whether the shape is square or not, it is the object's preference for the appearance and shape of the comb product, the square shape is recorded as 10, and the shape is not square is recorded as 1. d as 10, and the light color is recorded as 1.

3.3 Kappa Function to Test for Collinearity

The Kappa function is to test and analyze several groups of data, indicating whether there is collinearity between the two groups of data, and the parameters indicating the consistency between the two are named Kappa statistic, and its basic formula (6) is as follows:

$$Kappa = (P_0 - P_e)/(1 - P_e), \quad (6)$$

Table 4. Regression result table.

Variable	Coefficient	Std.Error	T value	Prob.
C	8.1066	6.2564	13.002	0.0001
X ₁	0.6271	0.8433	-1.463	0.1479
X ₂	-1.0154	0.1490	1.544	0.1265
X ₃	0.1215	0.1305	2.510	0.0141
X ₄	-0.6441	0.1546	-2.584	0.0116
R-squared	0.5427			

in it,

$$P_0 = \frac{a+d}{n}, P_e = \frac{(a+d)(a+c)(c+d)(b+d)}{n^2}. \quad (7)$$

In this paper, the collinearity test is carried out on the four variables, and the Kappa function value is 4.216389 calculated by the R language, that is, there is low collinearity between the variables, so regression analysis can be used.

3.4 Multiple Linear Regression

Multiple regression refers to a regression model of one dependent variable and multiple independent variables. R language software is used to establish a multiple linear regression model (Table 4).

The linear regression Eq. (8) between the overall score and each influencing factor can be initially obtained:

$$Y = 0.6271 \times X_1 - 1.0154 \times X_2 + 0.1215 \times X_3 - 0.6441 \times X_4 + 8.1066. \quad (8)$$

According to the regression analysis and calculation, the coefficients of each variable obtained are positive, negative, positive, and negative, respectively, indicating that the appearance with complex patterns, no handles, dark colors, and unsquare shapes is more attractive to users.

4 Improvement Plan

According to the analysis of the appearance factors of Changzhou combs, one of the combs is used as the carrier to apply the design scheme to the modern design, as shown in Fig. 1. According to the research results, an improved design scheme for the appearance of the comb is carried out, as shown in Fig. 2, to verify the above results.

Judging from the appearance of the product, both are cambered handleless combs. Both the overall shape and the decoration on the wooden comb are separated from the middle part, and the left and right sides are symmetrical. The shape of the upper comb is closer to a complete semicircle, while the lower comb uses the shape of the dragon



Fig. 1. Existing comb style.



Fig. 2. Improvement diagram to meet the scheme.

body and tail to integrate into the shape of the comb, which is more beautiful in form and rhythm.

From the pattern point of view, the decoration is also significantly increased. “When it comes to decoration,... in addition to the subject matter it takes, there is a more important layer, which is the atmosphere and effect it creates on the main body of the decoration and the entire environment, which can subtly affect people’s spirits. Because it directly reveals the laws of formal beauty.” [5] In the picture, both of them depict the pattern of double dragons playing with beads on the comb. The dragons have the same shape. They both draw the dragon’s head on one side of the wooden comb, and then draw the dragon’s body from the entire back of the comb, and finally draw the dragon’s body. Draw the tail on the other side of the wooden comb. However, the former uses lines as the main decoration, while the latter integrates the pattern into the overall shape of the wooden comb for decoration. In terms of color, the former only uses a single wood color, while the latter uses green, orange, and gold to describe the pattern on the basis of the wood color. The overall form of the former is dominated by lines, while the latter appears in the form of color blocks. It can be seen that compared with the most basic pure lines and single-color modeling, the bright and colorful blocks can present a three-dimensional sense, which is more layered, vivid and attractive visually, as shown in Fig. 3.

In summary, it can be seen from the shape, pattern, shape and color of the comb that the decorative appearance of the comb is increasing.



Fig. 3. Pattern effect comparison.

5 Conclusion

Changzhou comb is a splendid treasure of the Chinese nation. The patterns, shapes, colors and shapes on the comb provide a rich source of value for cultural design, making cultural and creative products endowed with deeper cultural connotations. The design of Changzhou combs is complicated and multi-layered, and the availability and rationality of Changzhou combs should be increased for specific users. The above research compares the existing comb style designs by extracting four factors of no handle, complex pattern, dark color and irregular shape, and proposes an improvement plan based on the data analysis conclusions. After verification, the appearance of the comb is enhanced. This method can provide a reference for the innovative research and development of Changzhou comb. In the future, through extensive research and in-depth analysis and systematic operation extraction, the design angle of Changzhou comb can be inspired, so that excellent traditional cultural products can be inherited and carried forward, and cultural and creative products that are popular with the public can be designed, so that excellent traditional cultural elements can be incorporated in art design.

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