Design Evaluation of Campus Cultural and Creative Products based on Analytic Hierarchy Process Taking the design of Guangdong University of Finance and Economics as an example

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Abstract—Programs for campus cultural and creative design and development nowadays have a poor post-evaluation link. This study builds an evaluation model for campus cultural and creative product creation and quantitatively assesses several programmes for product development in accordance with the features and specifications of the produced goods. First, based on the theory of emotional design, the evaluation index system of campus cultural and creative product development was created by using literature research and other methods, breaking down the development into a number of indicators to be evaluated, using the hierarchical analysis method (AHP) to determine the weight value of each indicator, and finally arriving at a comprehensive score and ranking of each development. The accuracy of the ranking results was confirmed by the sales data of three campus cultural and creative product design solutions in order to increase the validity of the fundamental assessments of various campus cultural and creative product development strategies, to realize the convergence of cultural and economic benefits of campus cultural and creative products, and to offer fresh perspectives for the design evaluation research of campus cultural and creative products. The research findings, however, are rather limited because campuses in various countries have some variations in the connotation of culture.

Keywords- campus cultural and creative products; product design; development evaluation; hierarchical analysis method;

1 INTRODUCTION

Campus culture is the soft power of campus, and campus cultural creative design activity is a new means of spreading campus characteristic culture, as well as an important way to spread campus image and become a channel to deepen the outside world's understanding of campus, while improving our teachers' and students' cultural self-confidence.

Currently, the development of campus cultural and creative products in China has been delayed and is still in the exploratory and development stages. Homogenization, a lack of creativity, and limited product forms[1][2] due to insufficient development costs are all prevalent issues in the creation of campus cultural and creative products that fail to meet the needs of users

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completely[3][4]. All of these issues represent the flawed and unscientific design method of campus cultural and creative products, which significantly decreases product quality. This implies that high feasibility and high value are required for the creation of campus cultural and creative products nowadays, therefore it is critical to evaluate and screen development ideas swiftly and efficiently.

Many scholars have conducted design and development evaluation studies on various types of products in the research on the evaluation of cultural and creative product design and development, primarily in terms of tourism cultural and creative products, museum cultural and creative products, and traditional cultural and creative products. Qi Feihe et al., for example, combined cultural and creative product design and assessment into a contextual system and provided an evaluation index system for the results of cultural and creative product design for Hunan culture[5]. Li Wen develops a museum cultural and creative product design evaluation index system based on cultural value and presents a museum cultural and creative product design assessment model[6]. Wang Luyao et al. gathered product design features and traits from three levels: physical setting, context, and mood, assessed user preferences, and built a museum cultural and creative design evaluation system[7]. Some scholars have also used new technologies to develop and improve the evaluation techniques of cultural and creative products[8][9][10].

The current research on the evaluation of cultural and creative works focuses primarily on three tiers of evaluation criteria, which are surface to surface and shallow to deep, demonstrating the comprehensiveness of the evaluation system. The assessment criteria system is ultimately formed through the empowerment and ranking of the evaluation criteria in the selection of evaluation criteria.

Affective design theory is a credible and practical theory to employ in evaluating the cultural influence of a product since it considers the cultural and emotional components of a product. A rising number of research have shown that emotive design evaluation is useful. Liu Lijuan et al., for example, developed a packaging design evaluation approach based on three levels of emotional interaction[11], a picture book emotional design evaluation index system[12], and a wedding gift packaging emotional evaluation index system[13]. Meanwhile, several research attempt to synthesise the emotional design evaluation index system and the emotional evaluation of product design[14] in order to improve design evaluation job. Despite the fact that emotional design theory is used to evaluate diverse product designs, there is a paucity of research on the level of cultural and creative products. Some contemporary studies on the assessment of cultural and creative products are emotional in the sense that they employ contextual experience to develop an evaluation system[6][9], but they fail to answer the challenge of emotional design evaluation of cultural and creative products.

The current research on campus cultural and creative product design focuses mostly on the product development and design level, specifically on how to extract and convey college cultural and creative elements. Some studies examine the design through design courses at the level of design evaluation of campus culture and creative product development[15]. Wei Wei suggested a strategy for evaluating campus cultural and creative products based on experience and cultural features[16], but design evaluation has been a relatively weak link in design training and the transformation of design practise results.

In conclusion, preliminary findings from the study of cultural and creative product design have been obtained. In terms of research on the development and evaluation of campus cultural and creative product design, relevant scholars have included design evaluation as part of the product development and design process in the study of campus cultural and creative product design, and there is a lack of research specifically on the design and development evaluation of campus cultural and creative products. This paper proposes an evaluation model for the development of campus cultural and creative products based on emotional design theory and the use of hierarchical analysis, and validates the design and development solutions derived from the screening, based on an in-depth analysis of existing product design and development of cultural and creative products. The remainder of the paper is organised as follows: Section 2 goes into the method's application and the design of the assessment model in depth. Section 3 provides a case study to explain how to use the model. Section four conducts a test and summarises the results. Section 5 summarises and gives recommendations for the design of campus cultural and creative products.

2 EVALUATION METHOD

2.1 Concept and basic principle of hierarchical analysis

A.L. Saaty, an American operations researcher, proposed the Analytic Hierarchy Process (AHP) in the 1970s. It is a multi-objective decision analysis method that combines qualitative and quantitative analysis methodologies to quantify decision problems by building a multi-layer analytical structural model and establishing the weights of constituent factors at various levels[17]. The essential concept of hierarchical analysis is decomposition followed by synthesis. Based on this systematic idea, it is necessary to decompose the analysed problem into different levels of constituents, form a multi-layer analysis structure model based on the relationship of advantages and disadvantages, and finally boil down to the problem of the relative weight of the bottom level relative to the top level.

2.2 Construction of evaluation index system

Campus cultural and creative design is no longer restricted to utilitarian aspects, but there is a greater demand for the campus cultural traits portrayed in the product and the rich emotional factors incorporated in it[18]. "Products must be appealing, effective, intelligible, entertaining, and intriguing." Donald Norman wrote in his book *Emotional Design*[19]. As a result, the design and development of campus cultural and creative products should delve deeply into the cultural aspects of the campus in order to suit the needs of consumers based on emotional design theory.

Based on consulting industry experts, grasping the factors related to the development of emotional campus culture and creativity, and referring to relevant research results, A of campus cultural and creative product development is divided into three aspects of evaluation: instinctive level B_1, behavioural level B_2, and reflective level B_3, which together construct the first-level evaluation index set $B = \{B_1, B_2, B_3\}$, based on three different dimensions of design, namely instinctive, behavioural, and reflective in the theory of emotional design. The instinctive level can construct the secondary evaluation index set $B_1 = \{C_1, C_2, C_3, C_4\}$ from four aspects: building

form, campus environment colour, material, and price; the behavioural evaluation level can construct the secondary evaluation index set $B_2 = \{C_5, C_6, C_7, C_8\}$ from four aspects: function, ease of understanding, ease of use, and feeling. The reflective evaluation level can be divided into four aspects of connotation semantics, campus memory, teacher and student image and message communication to construct the secondary evaluation index set $B_3 = \{C_9, C_{10}, C_{11}, C_{12}\}$, which constitutes the evaluation item layer C and finally obtains the evaluation index system of campus cultural and creative product development. Figure 1 shows the evaluation index system of campus cultural and creative product development.

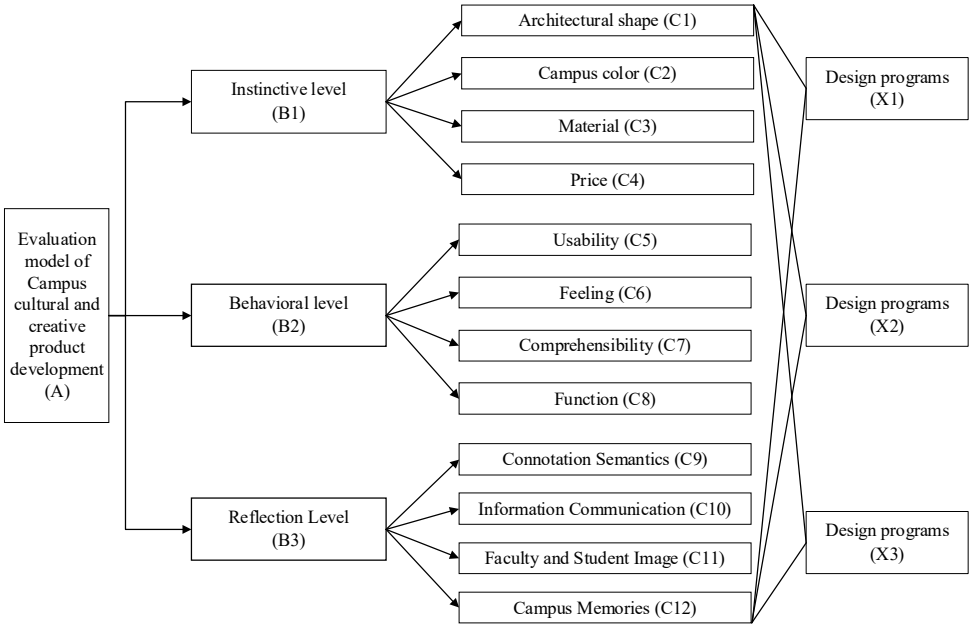

Figure 1 Evaluation index system of campus cultural and creative product development

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2.3 Construction of judgment matrix of evaluation indexes

The quantitative data of the hierarchical analysis technique must be collected by generating a judgement matrix, and the 9-level scale method is utilised according to the principle of pairwise comparison of pro-elements of the target layer with each sub-element of the factor layer, as shown in Table. 1.

Table. 1 Meaning of scales 1 to 9 in the hierarchical analysis method

Scale	Connotation
a_{ij}= 1	Factor i is equally important to Factor j in the above level.
a_{ij}= 3	Factor i is slightly more important than Factor j.
a_{ij}= 5	Factor i is more important than Factor j.
a_{ij}= 7	Factor i is much more important than Factor j.
a_{ij}= 9	Factor i is rather more important than Factor j.
a_{ij}= 2，4，6，8	The importance of Factor i and Factor j is between the middle value of adjacent judgment.
a_{ij}= $1/a_{ij}$	If the importance ratio of Factor j and Factor i is a_{ij}, then the importance ratio of Factor i and Factor j is $a_{ij} = 1/a_{ij}$.

Quantifying the decision maker's preference judgments to form a judgment matrix.

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1i} & \ldots & a_{ij} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2i} & \cdots & a_{2j} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{i1} & a_{i2} & \cdots & 1 & \cdots & a_{ij} & \cdots & a_{in} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{j1} & a_{j2} & \cdots & a_{ji} & \cdots & 1 & \cdots & a_{jn} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{ni} & \cdots & a_{nj} & \cdots & 1 \end{bmatrix} = (a_{ij})_{n\times n}$$

where the value a_{ij} indicates the relative importance of factor A_i compared to factor A_j. If we set the importance of the elements of each factor layer for the target layer as C_1，$\cdots$，C_i，$\cdots$，C_j，$\cdots$，C_n, then have

$$a_{ij} = C_i/C_j \tag{1}$$

2.4 Determine the weight value of each indicator

The judgment matrix $A = (a_{ij})_{n\times n}$ is constructed by the pairwise comparison method, and then the sum-product method is applied to calculate the eigenvectors of this judgment matrix. Next, the elements in matrix A are normalized by columns through formula (2) to obtain $\bar{a}_{ij}$, and then the same rows of the normalized matrix are summed up in each column through formula (3) to obtain $\widetilde{w}_i$. Then, the weight vector w_i is obtained by dividing the summed vector by n by Eq. (4). finally, the maximum characteristic root is calculated by Eq. (5).

$$\bar{a}_{ij} = a_{ij}/\sum_{k=1}^{n} a_{kj}\ ,\ \ i,j = 1,2,\cdots,n \tag{2}$$

$$\widetilde{w}_i = \sum_{j=1}^{n} \bar{a}_{ij}\ ,\ \ i = 1,2,\cdots,n \tag{3}$$

$$w_i = \widetilde{w}_i / n \tag{4}$$

$$\lambda_{max} = \frac{1}{n}\sum_{i=1}^{n}\frac{(Aw)_i}{w_i} \tag{5}$$

where $(Aw)_i$ denotes the ith component of the vector Aw.

2.5 Consistency check

After determining the weight values of each index layer, the consistency test of judgment matrix A is required, and its consistency index $C.I.$ is calculated by equation (6).

$$C.I. = (\lambda_{max} - \mathrm{n})/(n-1) \tag{6}$$

where λ_{max} is the maximum eigenvalue of the judgment matrix A.

Since the random consistency indexes of different scales are different, the consistency ratio $C.R.$, a consistency evaluation index, needs to be calculated by Equation (7), where $R.I.$ is the random consistency index. For the consistency ratio, generally when $C.R. = 0$, A can be called a completely consistent matrix; when $C.R. < 0.1$, A can be called a consistent matrix; when $C.R. > 0.1$, A is said not to be consistent. When the judgment matrix has satisfactory consistency, λ_{max} is slightly greater than the matrix order n, and the remaining characteristic roots are close to zero. Finally, on this basis, each evaluation element will be ranked in a hierarchical total, comprehensive evaluation and graded study.

$$C.R. = C.I./R.I. \tag{7}$$

After completing the consistency test, the calculation of the weight W for each level is based on the above. The weight values of each detailed evaluation index in the sub-criteria layer need to be normalized, and finally the weight values of each evaluation index $C_1, C_2, \ldots, C_n$ are calculated and ranked comprehensively as the reference standard of the evaluation model.

Using the comprehensive evaluation summation model to normalize the weight values of each detailed evaluation index in the sub-criteria layer according to Equation (8), the comprehensive ranking of the weights of each evaluation index is calculated and used as the reference standard of the evaluation model.

$$E = \sum_{i=1}^{n} W_i M_i \tag{8}$$

Where E is the comprehensive evaluation value; W_i is the weight value of the i evaluation index; M_i is the evaluation score of the i evaluation index, and finally the total score of the design method is obtained, and the total score of each design solution to be evaluated is ranked by this method.

3 CASE STUDY

According to the campus cultural and creative product design evaluation index system and the judgement matrix construction. To confirm the correctness of the calculation findings, a total of 40 persons were invited to establish an evaluation team object, which included 10 product designers, 10 graduate students in industrial design, and 20 teachers specializing in design.

The judgment matrix $A = (a_{ij})_{m \cdot n}$, $(i = 1,2,\cdots,n; j = 1,2,\cdots,n)$ was constructed by comparing each evaluation index with a scale of 1 to 9 on a two-by-two basis according to the hierarchical analysis method, and the judgment matrices and weights of the criterion level, instinct level evaluation index, behavior level evaluation index and emotion level evaluation index are shown in Table. 2, Table. 3, Table. 4 and Table. 5, respectively.

Table. 2 Criterion level judgment matrix and weights

Evaluation Indicators	B_1	B_2	B_3	**Weights** w
B_1	1	2	4	0.56
B_2	$\frac{1}{2}$	1	3	0.32
B_3	$\frac{1}{4}$	$\frac{1}{3}$	1	0.12

Table. 3 Judgment matrix and weights of instinctive level evaluation indicators

Evaluation Indicators	C_1	C_2	C_3	C_4	**Weights** w
C_1	1	2	3	5	0.43
C_2	$\frac{1}{2}$	1	5	$\frac{1}{5}$	0.19
C_3	$\frac{1}{3}$	$\frac{1}{5}$	1	$\frac{1}{5}$	0.10
C_4	$\frac{1}{5}$	5	5	1	0.31

Table. 4 Behavior level evaluation index judgment matrix and weights

Evaluation Indicators	C_5	C_6	C_7	C_8	**Weights** w
C_5	1	3	$\frac{1}{5}$	$\frac{1}{6}$	0.11
C_6	$\frac{1}{3}$	1	$\frac{1}{5}$	$\frac{1}{4}$	0.07
C_7	5	5	1	$\frac{1}{5}$	0.27
C_8	6	4	5	1	0.55

Table. 5 Judgment matrix and weights of emotional level evaluation indicators

Evaluation Indicators	C_9	C_{10}	C_{11}	C_{12}	**Weights** w
C_9	1	4	$\frac{1}{5}$	$\frac{1}{5}$	0.18
C_{10}	$\frac{1}{4}$	1	4	$\frac{1}{3}$	0.20
C_{11}	5	$\frac{1}{4}$	1	$\frac{1}{3}$	0.19
C_{12}	5	3	3	1	0.43

Table. 6 Consistency calculation results

Consistency indicators	A	B_1	B_2	B_3
λ_{max}	3.00	4.04	4.04	4.02
CI	0	0.04	0.04	0.02
RI	0.52	0.89	0.89	0.89
CR	0	0.01	0.01	0.01

The consistency test was performed after determining the weight values of each index, and the calculated values were all less than 0.1, as shown in Table. 6, proving that the judgement matrix is consistent.

Table. 7 Comprehensive ranking of the weight of each evaluation index

Target layer A	Guideline layer B	Weights	Guideline layer C	Weights
Evaluation of Campus Cultural and Creative Product Design A	Instinctive level B_1	0.56	Architectural shape C_1	0.24
			Campus Color C_2	0.11
			Material C_3	0.06
			Price C_4	0.17
	Behavioral level B_2	0.32	Usability C_5	0.04
			FeelingC_6	0.02
			ComprehensibilityC_7	0.09
			Function C_8	0.18
	Reflection Level B_3	0.12	Connotation Semantics C_9	0.02
			Information CommunicationC_{10}	0.02
			Faculty and Student ImageC_{11}	0.02
			Campus MemoriesC_{12}	0.05

The indicator weights in the evaluation model were determined based on the above computation of the weight W for each level, and the results are displayed in Table. 7. From the distribution of evaluation weights in Table. 7, the highest weight value (0.56) was assigned to the instinctive level in the guideline level B, indicating that this level is the most valued in the development of campus cultural and creative product design; followed by the behavioral level and finally the reflective level. In the criterion level C, the highest weight value is architectural shape. The instinctive dimension of campus cultural and creative design is reflected through campus architectural shape, which has a high weight value of 0.24 in this evaluation system; followed by function (0.18). As a category of products, functionality is an important part of the value provided by the product to the user, and is an important attribute to distinguish different product categories[20]. The third factor is cost (0.17). Campus cultural and creative products compete as commodities with campus professors and students, alumni, and other consumer groups, and their pricing has a direct impact on customers' purchasing decisions; the fourth weight is campus colour (0.11). Campus colour is an important part of campus culture that can stimulate the emotions of campus teachers and students and plays an important role in enhancing the guiding and cohesive effect of campus culture, and attention should be paid to bringing this attribute of campus cultural and creative products into play in the application of design development. Other weighing factors are ease of comprehension, material, campus memory, ease of use, feeling, connotative semantics, faculty and student image, and message delivery, in descending order.

In order to verify the validity of the evaluation model, based on the above constructed model, the evaluation model of Guangdong University of Finance and Economics for the development of cultural and creative product design is constructed based on the campus culture, and three campus cultural and creative notebooks are selected as the solutions to be evaluated, see Figure 2 The campus cultural and creative notebook solutions to be evaluated.

Figure 2 Campus creative notebook program to be evaluated

The above three groups of design and development solutions were simultaneously evaluated by the evaluation team objects, combined with the evaluation index system of campus cultural and creative product development in Fig. 1, and the three solutions were scored in the range of 0~10 on a Likert scale[21] from $B_1 \sim B_2$ and $C_1 \sim C_{12}$, etc. The average value was taken to establish the original data matrix, which is shown in Table. 8.

Table. 8 Original Score Sheet for Campus Cultural and Creative Product Design and Development Program

Evaluation Indicators	Programs X_1	Programs X_2	Programs X_3
Architectural shape C_1	5.36	6.82	6.91
Campus Color C_2	5.90	6.91	5.91
Material C_3	5.66	7.09	7.46
Price C_4	5.82	6.73	7.00
Usability C_5	6.64	6.91	6.64
FeelingC_6	6.01	7.36	7.01
ComprehensibilityC_7	6.64	7.18	6.98
FunctionC_8	6.18	7.46	6.64
Connotation SemanticsC_9	5.64	7.09	7.09
Information Communication C_{10}	6.18	6.82	7.27
Faculty and Student Image C_{11}	5.63	7.09	7.09
Campus Memories C_{12}	5.82	7.55	7.36

Finally, the integrated coefficient method was introduced through a group of decision makers, such as professional designers and design teachers, and the above comprehensive evaluation summation model was used to calculate the comprehensive evaluation value of the campus cultural and creative product design and development programme, as shown in Table. 9.

Table. 9 Comprehensive evaluation value of campus cultural and creative product design and development program

Evaluation Indicators	Programs X_1	Programs X_2	Programs X_3
Architectural shape C_1	1.2864	1.6368	1.6584
Campus Color C_2	0.649	0.7601	0.6501
Material C_3	0.3396	0.4254	0.4476
Price C_4	0.9894	1.1441	1.19
Usability C_5	0.2656	0.2764	0.2656
FeelingC_6	0.1202	0.1472	0.1402
ComprehensibilityC_7	0.5976	0.6462	0.6282
FunctionC_8	1.1124	1.3428	1.1952
Connotation SemanticsC_9	0.1128	0.1418	0.1418
Information Communication C_{10}	0.1236	0.1364	0.1454
Faculty and Student Image C_{11}	0.1126	0.1418	0.1418
Campus Memories C_{12}	0.291	0.3775	0.368
Total	6.0002	7.1765	6.9723

According to the evaluation results, the second notebook received the highest score of the three campus cultural and creative product development solutions, followed by the first, all with scores greater than 6. The first notepad received the lowest score. The top four indicators are all part of the product composition that customers can see or feel directly, and they have a higher direct impact on customers. The architectural shapes and colours utilised on the object, for example, can be visually appealing and affect visual emotions[22]. Similarly, the product's functionality can satisfy people's usage needs, resulting in both positive and negative emotional appraisals of the functioning. Price is the most important element influencing college students' purchasing behaviour[23], according to price indicators. In contrast, the majority of the indicators listed lower require people to undergo emotional adjustment in order to attain them.

4 TEST OF EVALUATION RESULTS

The combined ranking of the three creative items must be confirmed after acquiring the ranking results. The technique of verification was based on the market sales of the three notebooks throughout the graduation season. Table. 10 presented the final data, and the ranking results were found to be compatible with the assessment findings produced by introducing hierarchical analysis, proving the method's practicality.

Table. 10 Summary of data of 3 products in the campus market

Product style	Product Images	Sales
Campus Architecture Notebook		28
Campus hard cover notebook		65
Campus Cartoon Notebook		39

According to the vertical ratings of various products in Table 8, the second notebook is the best-selling of these three notebooks, thanks to its representative campus colours and unusual patterns that consumers prefer. Architectural shape, function, and pricing are the top three factors in its full examination, in that order. The following two notebooks share the same indicators in the top three of their full evaluation, showing that the usage of campus cultural components and the product's overall worth are the most competitive aspects of its creation. As a result, when developing campus culture and creativity products, we must constantly delve deeper into campus

characteristics and culture, increase the functional value of the products for consumers, and improve the cost performance of the products. These three notebooks have poor ratings in connotation semantics, image of professors and students, and feelings, showing that they are not in high demand and do not suit the needs of consumers as well as the first three indications for campus cultural and creative items.

The third product received the greatest architectural shape index score, thanks to its elegance and aesthetic diversity. The functional index refers to the functional qualities and functional value of campus cultural and creative products. The second one receives the highest grade since it has a high functional value due to its lifespan and moderate weight advantage. One of the most important factors influencing customer purchasing decisions is the value indicator. The third notebook has the highest score, which does not have a little difference in score from the second one but is popular among consumers due to its more expensive materials and outstanding cost performance. These three items differ in each indicator within the instinct level criterion tier, as well as within the criterion tier at other levels.

In summary, the second notebook wins due to its more natural use of shape, colour, and function than the other two, as well as the ingenious integration of the three product elements that transmit emotion [22] in the design. Although both the first and third notebooks incorporate architectural elements into their designs, the architectural shapes are applied more rigorously in the design, and the application of colour is weaker and less aesthetically attractive than that of the second model. The price of the second notebook is quite low, in keeping with consumer preferences.

5 CONCLUSION

Based on hierarchical analysis, the evaluation model of campus cultural and creative product design development can better solve the drawback that most of the product design evaluation process relies excessively on designers' design experience, and it can also effectively help designers make fast, scientific and objective, and effective decisions in the limited campus cultural and creative development conditions. The hierarchical analysis approach is employed as the major method for the product evaluation process in this paper, and the method is effectively validated using three literary notebooks as examples. The evaluation index system is built from three aspects and twelve secondary indicators: instinct, behaviour, and reflection, and the method's practicality is validated by on-campus bazaar sales data of the three goods after deriving the weight values and complete ranking of each indication.

The evaluation findings explain the evaluation target as well as key influencing aspects of campus cultural and creative product development. It is necessary to give full play to the characteristic advantages in terms of campus characteristic cultural resources during development, to concentrate on expressing the basic attributes of the product and improving the overall value, to further enhance the attractiveness of campus cultural and creative product design, and to highlight the campus characteristics. Second, by focusing on the emotional level, the process of campus culture and creative product design should broaden the market and increase the brand value. However, because there are so many campuses, and campuses in different locations have diverse cultural connotations, the research findings are very limited.

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