

Sustainable Design Method for E-cigarette Products from the International Perspective

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Objectives: Tobacco companies from various countries are facing pressure to participate in global competition. How to improve the products' quality is important for the tobacco companies. In this study, based on the international perspective, the scale of E-cigarette product design evaluation is established, the brand value and cultural experience are integrated into the design activities, the design quality of the product is improved, and the culture is sustainable develop. **Methods:** This article constructs a product design system based on culture, experience and brand value perspectives by studying outstanding design brands product characteristics, using interviews and focus groups. This system includes design content in five aspects: value, aesthetics, function, innovation, and cultural experience. It further summarizes 20 design indicators. Using the analytic hierarchy process, the weight of the 20 design indicators is scored to determine the importance of guiding the design project. **Results:** In order to prove the effectiveness of the design index, combined with actual cases, in the process of designing a local brand of E-cigarette products in China, combined with relevant design indexes, compared with the index differences of international brands, focusing on 20 indexes The index with high weight value has studied the advanced aspects of international brand and completed the design of new products. The new proposal of the product was re-evaluated according to the design indicators. The new proposal has been significantly improved in all aspects. **Conclusion:** The actual results show that the established design indicators have certain guiding value for the development of new products. These indicators can be used as reference standards for design practice, and can also be used as standards for product design evaluation. They also have a certain value of new product development in other fields.

Key words: international perspective; analytic hierarchy process; evaluation system; electronic cigarette
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INTRODUCTION

In recent years, traditional tobacco products and Electronic cigarettes (E-cigarettes) are coexisted¹. With the continuous improvement of public health awareness, people are paying more and more attention to the use of E-cigarettes². E-cigarettes, or electronic nicotine delivery systems, are an atomizing device that relies on batteries to provide energy. It has a traditional cigarette smoking feel, but no tobacco the process of burning³. On the basis of not excessively changing the habits of smokers, users have more choices, which can help smokers quit smoking, and can also choose products with low health hazards to improve the quality of life⁴. In this context, the design quality of E-cigarette products has received more and more attention from enterprises, and the product quality has been improved through design improvements in the aesthetic experience, sense of value, and interaction performance of the product.

Chinese companies have become increasingly aware of the importance about globalization⁵, which has promoted the E-cigarette market to embark on a legal, standardized, and scientific development track as soon as possible. However, the advantages of Chinese enterprises' products in international competition are not obvious. The profit model of enterprises relying on price advantages and low labor cannot support the long-term stable development of enterprises, and it is easy to cause waste of resources. In October 2020, INTERBRAND released the "2020 Global Best Brand Ranking". The total value of the top ten companies on the list accounts for 50% of the total value of the list, but there is no Chinese company in the list of the top ten companies, enterprise. This has a certain relationship with the development stage of Chinese enterprises. It is also necessary to strengthen brand awareness and establish the concept of brand value in product development.

Companies use good product quality and product value experience to build brand value, while China has long been eager to have high-quality local brands⁶. The accumulated experience of existing brands will help other Chinese brands to grow, but they still need Speed up. Compared with ordinary brands, the

establishment of brand value must also pursue the combination of design and culture, such as combining with traditional cultural forms, reflecting the continuity of history and the naturalness of people's lives.

The practice of integrating cultural consumption and product innovation in international brands is also very common, focusing on innovating the cultural factors contained in traditional culture and incorporating modern new forms⁷. Brand research reports show that internationally renowned brands enhanced the high added value of the brand with local culture⁸. Chinese culture has long history. With the rapid growth of China's economy, consumers' demand for products with high cultural value is also increasing. Based on an international perspective, Chinese and foreign design teams conduct cross-cultural cooperation and can learn from mature international design experience⁹ and combine traditional culture with consumer trends, so that China can enter the world market through modern design channels and showcase its unique Cultural charm.

Based on the above research status, in Shanghai, we set up an international design research team, using focus group discussions and expert questionnaires, established new design indicators from the perspective of participating in international cooperation, and improved existing product design indicators. The product brand value and cultural experience value were integrated into the index system, and 20 design indexes were established to guide design practice. In order to better understand the importance of these indicators, this article uses Analytic Hierarchy Process (AHP) to score the weights of evaluation indicators, and ranks the indicators according to the size of their weight scores.

In the case practice stage, combined with the E-cigarette design project cooperated by Chinese tobacco brand (CTB), the design research team used the 20 design indicators summarized by the research to compare the international tobacco brand (ITB) with the CTB to find the difference between the two brands' products. In the design process, we focused on the high-weight indicators, and completed the design proposal based on the experience of ITB's indicators with high indicator scores.

Finally, in order to test the effectiveness of this approach, user questionnaire was used to compare the new CTB design scheme with the ITB products. The scores of the new CTB design scheme in each of the 20 design indicators were significantly improved. The results show that the design index system summarized in this paper has certain guiding significance for the improvement of design quality. In the process of design practice, this method can also be used as a reference for other types of product development and design.

METHODS

Analytic Hierarchy Process

Professor Saaty proposed the theory of the AHP¹⁰, which is a decision-making method that decomposes the factors related to decision-making into the target, criteria, index, and other levels and allows one to perform qualitative and quantitative analyses on this basis.

AHP can establish a scientific and reasonable product analysis model and determine the

weights of the corresponding design standards and sub-standards¹¹. In previous studies, such as those on the design of electric scooters, the testing of new technologies for unmanned driving, and the quantification of artwork, AHP has been applied for many purposes, such as evaluation, producing very good guidance effects¹²⁻¹⁴. AHP is usually used in product design and usability evaluation but is also widely used in other research fields. For example, Lee¹⁵ and Mangla¹⁶ apply the AHP in other fields such as Green supply chain management and risk analysis.

AHP is a mathematical tool that can calculate the priority vector of each indicator. The priority vector is called the main feature vector, which can be used to express the preference order of consumers in product development decisions. In the application of AHP, the research project is decomposed into multi-level indicators. This paper establishes a three-level evaluation system that includes the level of target, the level of criteria, and the level of index (Figure 1).

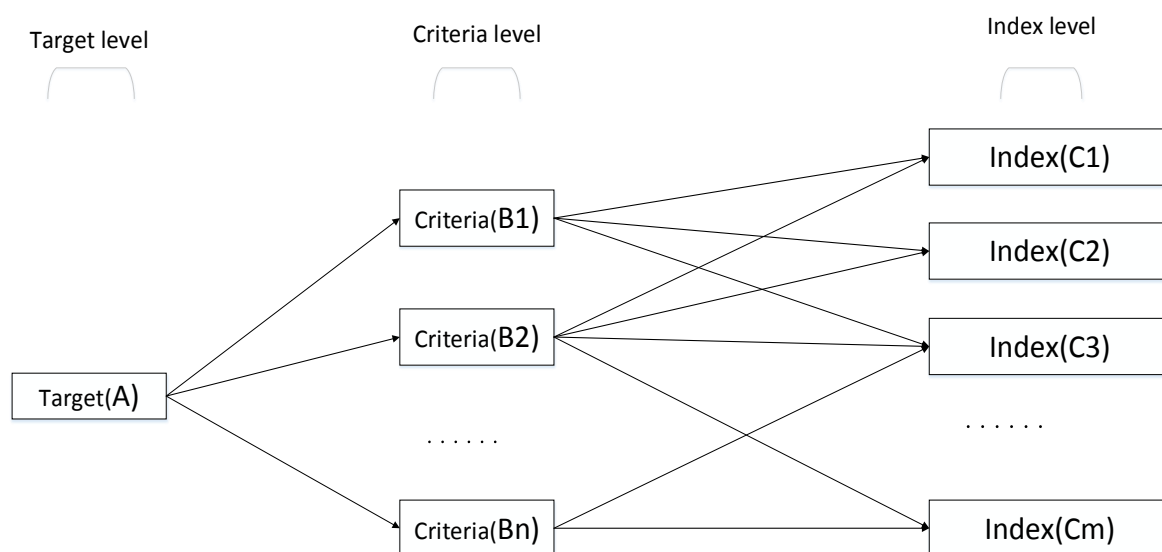


Figure 1 Analytic Hierarchy Process system.

According to the AHP, the weight of each index can be calculated by the judgment matrix in each level. Generally, the weight score of each index in the level is obtained via pairwise

comparison, e.g., the indicators B1, B2 in the target level A and the criterion

level B, ..., Bn are related, where $A = \{b_{ij}, i = 1, 2, \dots, n; j = 1, 2, \dots, n\}$. In this way, the judgment matrix can be formed (Table 1).

Table 1
Associated judgment matrix

A	B1	B2	...	Bn
B1	b_{11}	b_{12}	...	b_{1n}
B2	b_{21}	b_{22}	...	b_{2n}
...
Bn	b_{n1}	b_{n2}	...	b_{nn}

Using the nine-level scale method¹⁷, the relative importance is expressed by the numbers 1–9 and its reciprocal, and the expert score is completed to obtain the values in the matrix.

Next, use the geometric average method to solve the weight vector. The geometric average refers to the n-th root of the product of n observations.

Then, normalize the obtained results. The following three formulas provide the statistical process:

Find the product of the comparison result of this indicator and other indicators in each row of the judgment matrix M_i :

$$M_i = \prod_{j=1}^m C_{ij} \quad (1)$$

Where $i = 1, 2, \dots, m$; C_{ij} is the index in row i ; and column j , m is the number of comparison results between this index and other indexes.

Formula (2) is used to find the set averages a_i for each index:

$$a_i = \sqrt[m]{M_i} \quad (2)$$

Using an upper-level index and its corresponding lower-level index as a group, the next step is to normalize the results obtained and use the following formula to obtain the relative weight:

$$W_i = \frac{a_i}{\sum_{i=1}^m a_i} \quad (3)$$

According to the above judgment rules, score the evaluation indicators in each level and calculate the weight value of each indicator in each weight matrix based on the previous level.

Finally, each indicator's weight is calculated, and the priority indicator group is formed according to the weight value. These indicator

groups can be used to guide design practice. In this paper, the method of establishing a mapping relationship between these indicator groups and the perceptual vocabulary can effectively improve design reliability.

Integrate Brand Value to Establish aE-cigarette Product Design Evaluation System

Brands have become an inseparable and valuable component of economic life, and they are important guides that help people buy goods. In daily life, consumers like to buy goods from highly respected brands, which are able to provide consistent guarantees of quality, function, status, etc. Brands can convey the following six meanings to consumers:

- (1)Attributes: the first impression of the business category and brand on consumers.
- (2)Benefits: consumers who mainly buy for functional or emotional characteristics.
- (3)Values: the values of the brand and the sense of its values among consumers.
- (4)Culture: the cultural characteristics of the brand itself and the culture of the country (region) where it originated.
- (5)Personality: the uniqueness of the brand that differentiates itself from its competitors.
- (6)User: the characteristics of the purchasing crowd gathered by the brand.

For product research, Lin proposed a product hierarchy that includes form, function, and value. The product is an important element that determines its brand, and product quality is an important guarantee for such brands. Product form and function are important to enhance the product, and the value of the product is the core of the brand's value. Compared to common products, E-cigarette products' value experience in the process of using them is very important.

Norman studied human cognition and emotional systems in emotional design and divided them into the level of instinct, the level behavior, and the level reflection. The instinct level emphasizes people's intuitive experience of the product, focusing on appearance, touch, etc.; the design of the behavior level is the user's operating experience in the process of product function realization and reflection. At the level of reflection, the cultural connotations and symbolic meanings contained in the product focus on the emotional and memory-based experiences that products bring to users.

Through a literature review in the field of related product design focusing on the elements

of brand and cultural design, this paper summarizes the criteria levels of E-cigarette design and evaluation based on five aspects: value, experience, function, aesthetics, and creativity. Among these aspects, "value" mainly reflects the added value introduced by the product brand. By combining the content involved in these five aspects, this paper determines and sorts 80 three-level indicators.

To further enhance the effectiveness of the indicators, an expert group was formed by people with backgrounds in tobacco companies, product design, and brand management. We determined the final 20 indicators using the focus group method (See Figure 2).

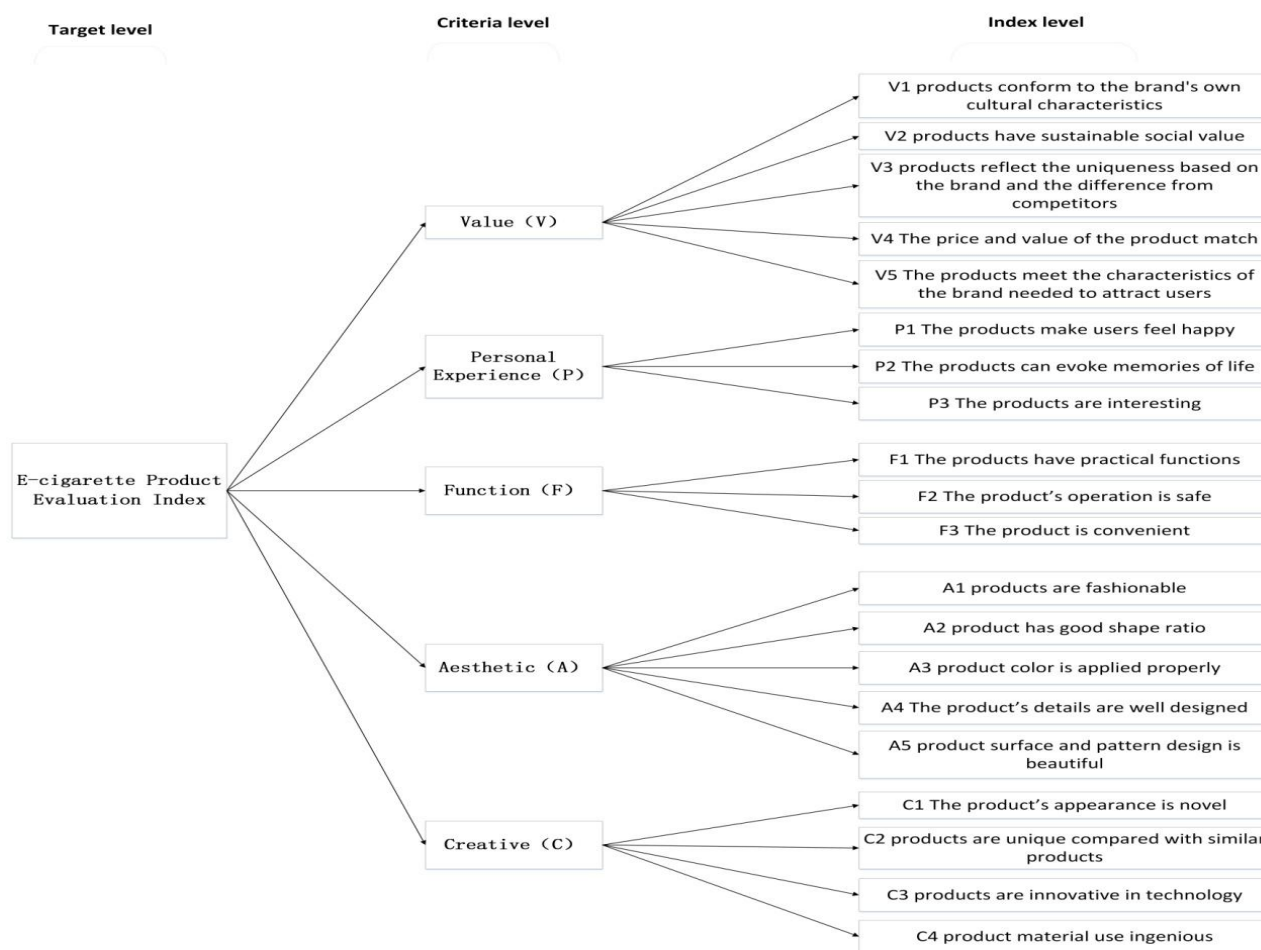


Figure 2E-cigarette product evaluation index.

Statistics on the Weights of Various Indicators of E-cigarette products

We scored the three-level indicators of the completed E-cigarette product evaluation using the nine-level measurement method and selected 40 evaluators with product design experience to

compare the indicators at all levels. We then analyzed the relevant data and applied formulas (1)–(3) to determine the weight of each indicator in the overall evaluation target (see Table 1).

These indicators were sorted according to their weight. The indicators with high scores have

more influence on the E-cigarette product design. indicators should be applied as much as possible.
In the design process, these high-scoring

Table 1
The Weight of Each Indicator in the Overall Evaluation Goal.

Target Layer	Criterion Layer	Weights	Indicators	The Weight of the Indicator to the Overall Goal	Index Layer Weight Sorting
E-cigarette product design rating indicators	Value (V)	0.340	V1 Products conform to the brand's own cultural characteristics	0.080	2
			V2 Products have sustainable social value	0.080	2
			V3 Products based on brands reflect uniqueness and differences from competitors	0.040	13
			V4 The price and value of the product match	0.040	13
			V5 The products meet the characteristics of the brand needed to attract users	0.100	1
	Personal Experience (P)	0.120	P1 The products make users feel happy	0.060	6
			P2 The products can evoke memories of life	0.040	13
			P3 The products are interesting	0.020	17
	Function (F)	0.150	F1 The products have practical functions	0.050	8
			F2 The product's operation is safe	0.050	8
			F3 The product is convenient	0.050	8
	Aesthetic (A)	0.135	A1 Fashionable products	0.020	17
			A2 Good product proportions	0.020	17
			A3 Proper application of product color	0.020	17
			A4 The product's details are well designed	0.025	16
			A5 Beautiful product surface and pattern design	0.050	8
	Creative (C)	0.255	C1 The product's appearance is novel	0.075	4
			C2 The product is unique compared to similar products	0.050	8
			C3 Innovative product technology	0.070	5
			C4 Ingenious use of product materials	0.060	6

According to the weight rankings of the indicators for the overall goal, the evaluation indicators were divided into three categories: important indicators (>0.05), secondary indicators ($0.05-0.03$), and general indicators (≤ 0.03) (see Figure 3). Among the 20 indicators, there are 7 important indicators. The product reflects its uniqueness based on its brand, and its differences from its competitors (V5) have the highest weight value. Other indicators include whether the product conforms to the brand's own cultural characteristics (V1) and whether the product includes sustainable development. Social value (V2) has a higher weight value, which shows that consumers have relatively high requirements for value perception. The scores of C1, C3, P1, and C4 are also in the top position, which indicates that users have high expectations

for E-cigarette products in terms of experience and innovation. The total weight is 52.5%. There are 8 sub-important indicators. V3 products reflect uniqueness based on their brand and whether are different from their competitors. V4 products match both price and value. P2 products can evoke memories of life, F1 products have practical functions, and F2 products operate safety. F3 products are convenient, while A5 products have beautiful surface and pattern designs and are unique compared to C2 products and similar products, with a total weight of 37%. The general indicators include 5 items, which are P3 products that make one happy, A1 products that have a fashionable taste, A2 products that have good styling proportions, A3 products that properly use color, and A4 products that are well-designed, with a total weight of 10.5%.



Figure 3 Comparison of the ITB E-cigarette products and CTB E-cigarette products.

DESIGN PRACTICE

Comparison of ITB Products and CTB Products

Combining the needs of the project, we formed a multinational design project team. The multinational team consists of 3 international designers and 3 Chinese designers. The professional background of the team includes brand planning and product design. With the 20 design indicators in five aspects summarized in this paper, the ITB and CTB E-cigarette products are compared (see Figure 3). According to various indicators, 30 men and 30 women with design background are invited to evaluate related products.

After comprehensive evaluation and statistics, the scores of each indicator are obtained (Table 2). The products of these two brands have similar scores in terms of "Aesthetics" (A1-A5), "Function" (F1-F3) and "Creativity" (C1-C4). When comparing "value" (V1-V5) and "personal experience" (P1-P5), ITB's product scores are higher than CTB, and these scores will be used as a reference for later design.

After an independent sample test, compared to the products of the ITB, the CTB and the ITB were shown to have significant differences in indicators such as V1, V2, V3, V4, P1, and P2 (see Table 2), which were statistically significant. Moreover, P3, A1, and the scores of indicators such as A4, C1, C2, and C4 indicate that the two brands have certain differences.

Table 2
Comparison of the Evaluation Scores of the ITB and CTB E-cigarette Products (Mean \pm Standard Deviation).

Indicators	Hongye	GIEN	<i>t</i> -Statistic	<i>p</i> -Value
V1 Products conform to the brand's own cultural characteristics	5.45 \pm 1.71	8.42 \pm 1.07	-8.048	<0.001 **
V2 Products have sustainable social value	5.38 \pm 1.52	8.57 \pm 1.03	-9.499	<0.001 **
V3 Products based on brands reflect uniqueness and differences from competitors	4.87 \pm 1.59	8.48 \pm 1.01	-10.501	<0.001 **
V4 The price and value of the product match	4.70 \pm 1.64	8.85 \pm 0.92	-12.068	<0.001 **
V5 The products meet the characteristics of the brand needed to attract users	5.20 \pm 1.54	8.50 \pm 0.96	-9.971	<0.001 **
P1 The products make users feel happy	4.53 \pm 1.38	8.43 \pm 1.02	-12.416	<0.001 **
P2 The products can evoke memories of life	5.43 \pm 1.92	8.32 \pm 0.92	-7.399	<0.001 **
P3 The products are interesting	7.40 \pm 1.65	8.48 \pm 0.92	-3.878	<0.05 *
F1 The products have practical functions	8.80 \pm 1.54	8.67 \pm 1.04	-1.379	0.063
F2 The product's operation is safe	8.63 \pm 1.35	8.38 \pm 1.06	0.941	0.133
F3 The product is convenient	8.03 \pm 1.69	8.48 \pm 1.05	-0.501	0.059
A1 Fashionable products	6.87 \pm 1.36	8.50 \pm 1.13	-2.267	<0.05 *
A2 Good product proportions	7.33 \pm 1.37	7.35 \pm 1.12	-0.341	0.074
A3 Proper application of product color	7.58 \pm 1.52	7.28 \pm 1.08	0.929	0.117
A4 The product's details are well designed	7.65 \pm 1.31	8.23 \pm 1.11	-1.434	<0.05 *
A5 Beautiful product surface and pattern design	7.85 \pm 1.42	8.37 \pm 1.17	-1.476	<0.05 *
C1 The product's appearance is novel	7.87 \pm 1.36	8.25 \pm 1.01	-1.964	<0.05 *
C2 The product is unique compared to similar products	6.72 \pm 1.66	8.43 \pm 1.09	-2.498	<0.05 *
C3 Innovative product technology	8.30 \pm 1.62	8.48 \pm 1.07	-0.992	0.309

C4 Ingenious use of product materials	7.60 ± 1.07	8.37 ± 1.05	-1.763	<0.05
** p< 0.001, *p < 0.05. Interpretation of the results: In the independent sample t-test results, ** indicates that the secondary indicators are significantly different, which is statistically significant, and * indicates that the scores of the secondary indicators have certain differences.				

Design and Evaluate the New design Proposal of CTB

The multinational design team combined design indicators begin to design the new CTB E-cigarette products. During the design process, indicators with a high weight value, especially the V1 products in the “value” indicator, conformed to the brand’s own cultural characteristics; V2 products featured sustainable social value; and V5 products conformed to the brand to attract users. The characteristics of C1 products in the “creative” index were considered novel, and the materials of C4 products were used with ingenuity.

On the other hand, in the comparison results of the two brands, the CTB E-cigarette

products’ value indicators (V1–V5) and the personal experience indicators (P1–P3) lagged far behind. For the design improvement, aiming at the “value” indicator combined with the brand value of CTB, we focused on the design direction of enhancing the serialization and overall sense of the product. In addition, the “personal experience” indicators (P1–P3) were related to the user’s experience, and the new design sought to enhance the user’s sense and cultural connotations.

After several weeks of practice, the design team completed the design proposals of CTB E-cigarette. The best design proposal (new CTB E-cigarette proposal) was selected for evaluation (see Figure 4).



Figure 4 New CTB E-cigarette product design proposal

In the design evaluation process, we invited 30 men and 30 women to take part in scoring the new CTB E-cigarette proposal. Combining the design evaluation indicators, the new proposal completed by the design team was scored item by item, and the average value of each index for the new design proposal was obtained according to the relevant statistics.

Through a comparison with the new CTB E-cigarette proposal and ITB E-cigarette products, the results showed that the new CTB E-

cigarette proposal had similar scores in aesthetics, function, and creativity. Compared with ITB E-cigarette products. About the “value” and “personal experience” indicators, by adding the brand value and traditional Chinese cultural elements, the new CTB E-cigarette proposal greatly exceeded CTB E-cigarette original products in terms of cultural experience and experience recognition (see Figure 5).

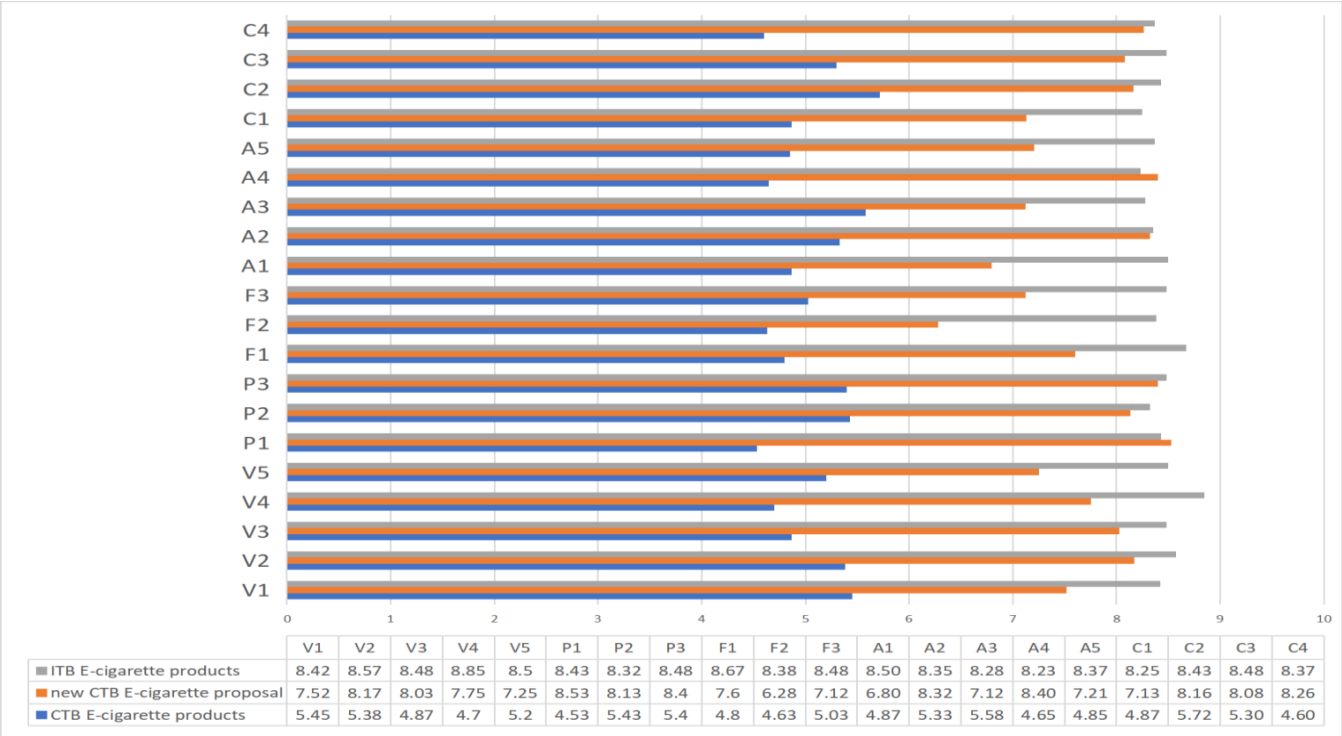


Figure 5Comparison chart of ITB E-cigarette products, new CTB E-cigaretteproposal, and CTB E-cigarettes

DISCUSSION
Scientific Evaluation Indicators can Improve E-cigarette products design quality.

If this evaluation index is used in the design process, the design decisions will be more accurate, and a reasonable design direction can be selected to effectively improve the quality of the design. Through a focus group and other methods, this paper established 20 evaluation indicators in 5 dimensions, covering the value, experience, functions, aesthetics, and creativity related to the E-cigarette products design. The establishment of scientific and reasonable evaluation indicators can ensure the quality of E-cigarette products design and innovation and help designers create excellent products that fit the times. In the design practice portion, for the weak indicators, the design was significantly improved. For example, comparing all indicators, the new CTB E-cigarette proposal scored higher than the original products. Even P1and A4 surpassed the scores of the ITB E-cigarette products. This shows that the scientific evaluation index can be used as the guiding index for design, while

applying more targeted design improvements is an effective design improvement method for the weak items in the index.

Some scholars have also tried to establish product evaluation indicators in related fields to improve design quality. For example, Li ¹⁸ combined the research under design thinking to establish product evaluation standards to help guide design. Chai ¹⁹ summarized the design indicators for cultural products combined with the Kano model, identifying consumer satisfaction as the basis for product design. This shows that the construction of an index system can provide scientific guidance for the design process.

Evaluation Indicators Combined with AHP Can Find Key Indicators about E-cigarette products

This paper calculated the weight of the E-cigarette products evaluation indicators with AHP. Among the index-level indicators, the V1, V2, and V5 indicators for the “value” factor and the C1, C3, and C4 indicators for the “creative” factor had higher weights. In design improvement, we must focus on these related

design indicators. Using the guidance of the weight value, the quality of the design was also improved, and the score of the new CTB E-cigarette proposal narrowed the score gap with the ITBE-cigarette products. These scores, however, were still unable to exceed the scores of the ITBE-cigarette products, possibly because the design need more time to understand the E-cigarette products in design practice. Indicators with low weight values, such as P3, A1, A2, and A3, were the basic design elements in the evaluation system, and their corresponding design effort was less significant than that for the indicators with a high weight.

The AHP can quantify a complex index system, determine the importance of the corresponding index in the system, and guide the design direction in the process of design decision-making. Similarly, Fan²⁰ used AHP to study the sustainable development of regional culture. And Wu²¹ used AHP Model for Aesthetic Product Design. Therefore, AHP is one means to improve product design.

The Promotion of Brand Value Can Promote the Value of Product.

In the tobacco field, E-cigarette products design combining “brand + product” has become a guarantee for the design of internationally renowned brands. Brands and products complement each other. The research on the ITBE-cigarette products in this paper shows that internationally renowned brands focus on establishing special value experiences beyond the functions and aesthetics of the product. Karjalainen T²² believes that brand recognition is important to promote the value of a product. Products bring the brand closer to consumers, and recognizable products help the brand have a more unique and profound impact. Brand is very important for E-cigarette products, as a brand is not just a trademark or slogan. Instead, a good E-cigarette brand can provide consumers with symbolic recognition that can be remembered, perceived, and learned.

The establishment of a brand is a relatively long process. Many brands have undergone nearly one century of development. However, China is facing the problem of low product brand value. Brand establishment for the E-cigarette

products can change this kinds of condition and help company establish sustainable culture

International Exchanges is Conducive to Sustainable Development

Focus on this project, we invited three international world-class designers to cooperate with Chinese designers. Adhering to the concept of combining brand value, design, technology, and materials, these teams improved CTBE-cigarette products design quality.

In the design practice stage, the international design team's concepts were integrated into the overall design, which promoted the exchange of design talents among designers with different cultural backgrounds. In this process, through a comparison of design indicators, the differences in product design were found. The CTBE-cigarette products were improved in the workshop, which increased the value of the product and improved its brand attributes. This kind of cross-cultural design team is conducive to studying the global value of E-cigarette products under an international background. Cultural exchange contributes to the sustainable development of culture.

CONCLUSIONS

Tobacco companies' E-cigarette products design is a relatively complicated process. It is not only a commercial issue, but also a sustainability issue. The E-cigarette products' design system established in this paper is based on value, experience, function, aesthetics, and creativity. It is useful for tobacco companies' product design. Furthermore, it will help enrich the design methods for other kind of products. In future research, we can consider the use of EEG, eye trackers²³, and other equipment for the objective evaluation of products, increase objective evaluation indicators, and enrich the available evaluation methods.

With the rapid development of the E-cigarette market, more and more attention is paid to the design of E-cigarette products. Establishing product design concepts from the perspective of the brand helps to provide consumers with more and better products. Well-designed products will also encourage tobacco companies to pay attention to users' health issues²⁴. This includes

data testing of E-cigarette users' physical health, health conditions during product use, and guidance on appropriate smoking habits. In the future, we will carry out Research and design in these areas.

Author Declaration

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