Application of EGM and Function Analysis Method to Product Improvement

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Abstract: A benign development of enterprises often need to invest a large amount of money in product improvement design, the meaning of improved design is 1) to inherit the advantages of the original product; 2) and to innovate. In order to improve the efficiency of improved design, a new method is proposed based on evaluation grid method and function analysis method. Firstly, the charm factor of the target product is obtained through the evaluation grid method. Then, the importance degree of each charm factor is analyzed by quantification theory. Finally, the innovative design of the target product is carried out in combination with the function analysis method. In this paper, highchair is used as a case study to confirm the effectiveness of the proposed method.

1. Introduction

In today's highly competitive market environment, the life cycle of products is shortened. In order to ensure the market share of products, it is necessary for enterprises to invest a large amount of money in the improved design of products [1]. Considering the product life cycle, different design strategies should be developed for products in different development periods. For those products in the mature stage, it is difficult to make breakthrough innovation in technology, but it is easier to make breakthrough in morphological diversity [2]. Therefore, in the face of consumer-oriented market environment, if we can accurately grasp the needs of consumers and combine with effective innovative design methods, we can improve the innovation and form diversity of mature products.

In-depth interviews with experts can help to dig out the attractiveness factors of products and then inherit these factors when products are improved. In addition, through the functional analysis of the product, on the one hand, the functional system boundary of the product can be replanned, on the other hand, the spatial layout of each form element can be rearranged. Therefore, this paper integrates evaluation grid method and function analysis method to improve product design, aiming to propose a new improved design method, which can be used to improve the innovation of mature products, so as to improve the market share of products and bring more benefits to enterprises. Section 2 describes the research methods and theories in detail. Section 3 describes the concrete implementation steps. Section 4 takes highchair as the case study to verify the effectiveness of the proposed method.

2. Theoretical Background

2.1 Evaluation Grid Method and Quantification Theory Type I

Evaluation grid method (EGM) is the main research method of Miryoku engineering, which is often used in conjunction with quantitative decision theory [3]. The main method of EGM is in-depth interview, which aims to capture people's potential cognition. Specifically, the EGM compares the target product A and B, and asks the evaluation structure map of the target product at three levels based on the difference between the two. Many scholars have applied EGM to the field of product design, such as product design education [4], product modeling design [5] and product interaction design [6]. Therefore, this article still uses EGM to construct the correspondence between personal perception and specific characteristics. In addition, in order to further clarify the relationship

between the various charm factors, it is necessary to set up a questionnaire survey and analyze the questionnaire data through quantification theory type I (QTTI). In the quantitative theory, QTTI is to establish the correspondence between the independent variable x and the dependent variable y [7]. Therefore, in this paper, EGM and QTTI are combined to obtain the charm factor of the target product, and finally provide reference for the subsequent improved design.

2.2 Function Analysis Method

The function analysis method is to treat the functional system of a product as a "black-box", and then transform specific "input" into the final "output" [8]. Some scholars have applied the function analysis method to the design of desert tree planting cart [9] and tea planting cart [10], proving that it is an effective research method. The specific steps are as follows: 1) Define the function "black-box" of the product based on "input" and "output ". 2) The overall function is broken down into a series of sub-functional units. 3) Use a square graph to represent the relationship between the secondary functions. 4) Draw the functional system boundary of the target product. 5) Find the appropriate elements to achieve the relationship between the various secondary functions. After transforming the functional "black-box" to "white-box", the secondary functions can be further limited to a certain number, and the spatial layout can be changed to obtain more possible forms. Therefore, the abstract design concept can be further concretized through the functional analysis of the product, and then the best feasible solution can be selected.

3. Implementation Procedures

This paper aims to propose an improved design method, based on the theory described in Section 2, the specific implementation procedures are described as follows. Step 1: Clear target product; Step 2: Conduct In-depth interviews; Step 3: Obtain three-layer evaluation structure map; Step 4: Conduct questionnaire; Step 5: Conduct quantitative analysis; Step 6: Obtain the importance of charm factor; Step 7: Draw the functional frame diagram for the target product; Step 8: Draw the spatial layouts for the secondary functional units of the target product.

Table. 1 Information about the target product

Brand model	**China** An-Furi	**China** Henryrabbit	**America** Babycare	**Japan** Farska	**Netherlands** Zaaz	**Denmark** Kadi	**Italy** Chicco
Product images							
Seat width (mm)	400	340	500	460	290	310	470
Weight (kg)	3.5	13	8.5	8	10	4	10.5
Texture	SUS/PLA	Wood	PLA/Fabric	Wood/Fabric	AL/PLA	PLA	SUS/PLA
Table size (mm)	430	480	520	470	400	350	450
Location of table							
Wheel	√	×	×	×	×	√	√
Folding	×	√	√	√	×	×	√

4. Case Study

4.1 Clear Target Product

This paper takes highchair as a case study. In order to avoid that the interview samples are not representative, 7 highchairs with the highest sales volume are finally determined as the interview materials after online sales platform retrieval and focus group discussion. Detailed information is shown in table 1.

4.2 Extract the Charm Factor of Target Product

In this stage, 7 highchairs have been identified as the stimulus information for in-depth interview. Then, the evaluation structure map as shown in figure 1 is obtained. In order to further clarify the importance of each charm factor, it is necessary to conduct a questionnaire survey, a total of 55 effective questionnaires were recovered. Finally, the data obtained by QTT Ⅰ analysis are shown in table 2. It can be seen that for "Secure" highchair, "Strong and stable" is a crucial factor; For "Convenient" highchair, "Save space" is a crucial factor; For "Warm and fragrant" highchair, "Seats are comfortable" is a crucial factor; For "Cost-effective" highchair, "Strong practicality" is a crucial factor. Therefore, the design innovation should first refer to these factors and their corresponding lower layer (CEI) factors. The CEI include "Steel timber", "Triangular braced", "Easy to remove plate", "Folding design", "Cool tone", "Adjustable backrest" and "Curvilinear form".

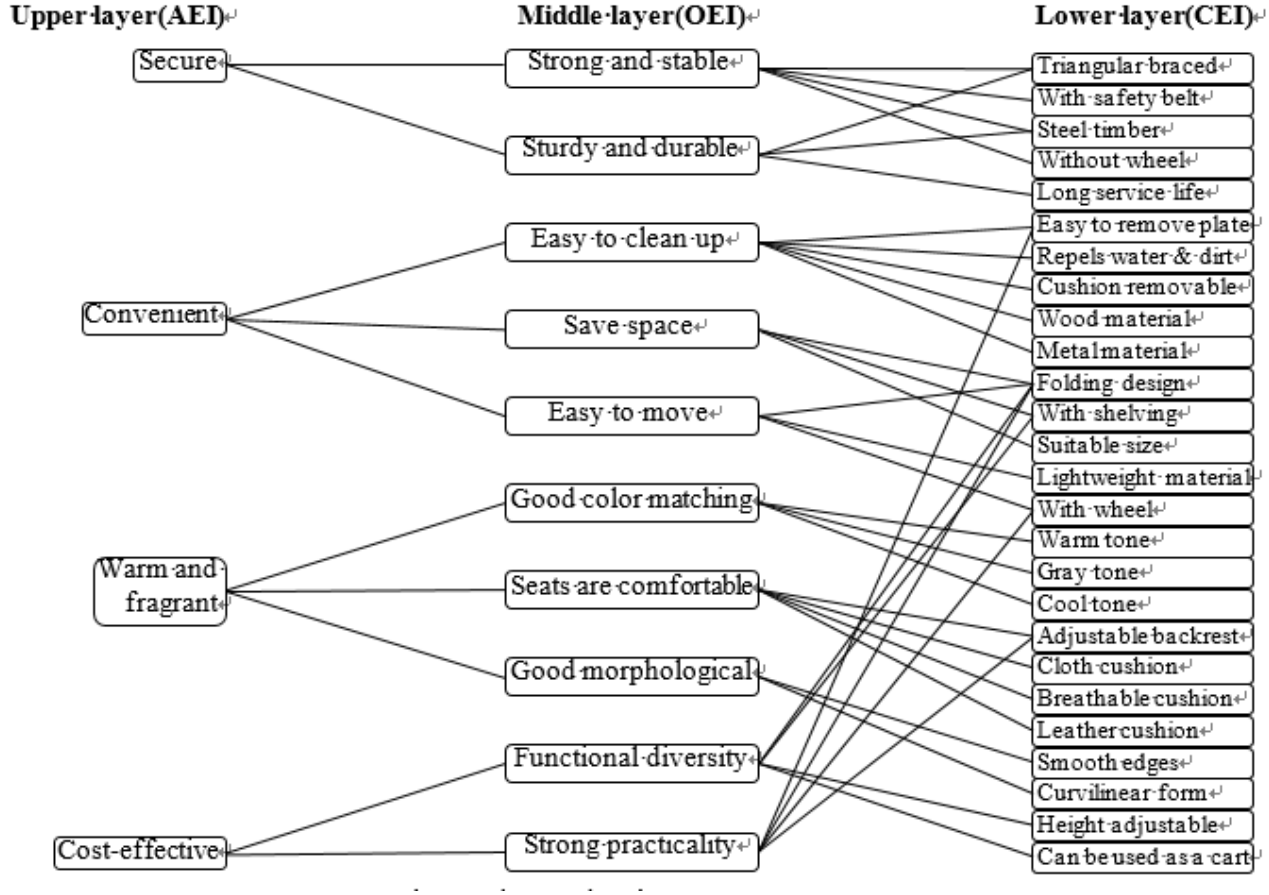

Fig. 1 The evaluation structure map

Table. 2 The results of QTT Ⅰ

	Original Item	Best Appeal Features	CS[a]	PCC[b]	Ranking
Result of QTT Ⅰ on “Secure”	X1 Strong and stable	Steel timber	0.8019	0.1882	1
	X2 Sturdy and durable	Triangular braced	0.1828	0.1601	2
	R			0.2223	
Result of QTT Ⅰ on “Convenient”	X1 Easy to clean up	Easy to remove plate	0.2058	0.2227	2
	X2 Save space	Folding design	0.3277	0.2631	1
	X3 Easy to move	With wheel	0.1665	0.1009	3
	R			0.3332	
Result of QTT Ⅰ on “Warm and fragrant”	X1 Good color matching	Cool tone	1.1622	0.1428	2
	X2 Seats are comfortable	Adjustable backrest	0.3893	0.1732	1
	X3 Good morphological	Curvilinear form	0.0386	0.0148	3
	R			0.2334	
Result of QTT Ⅰ on “Cost-effective”	X1 Functional diversity	Folding design	0.2434	0.1273	2
	X2 Strong practicality	Adjustable backrest	0.4619	0.2439	1
	R			0.2719	

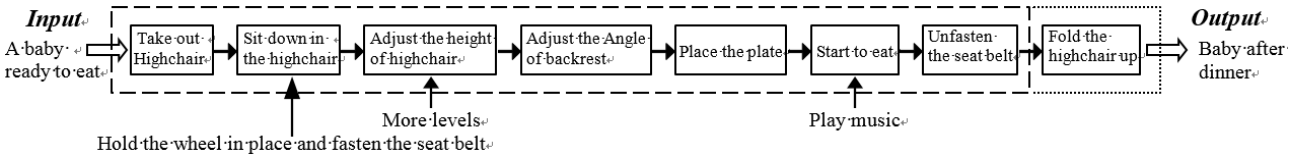

Fig. 2 The function analysis of highchair

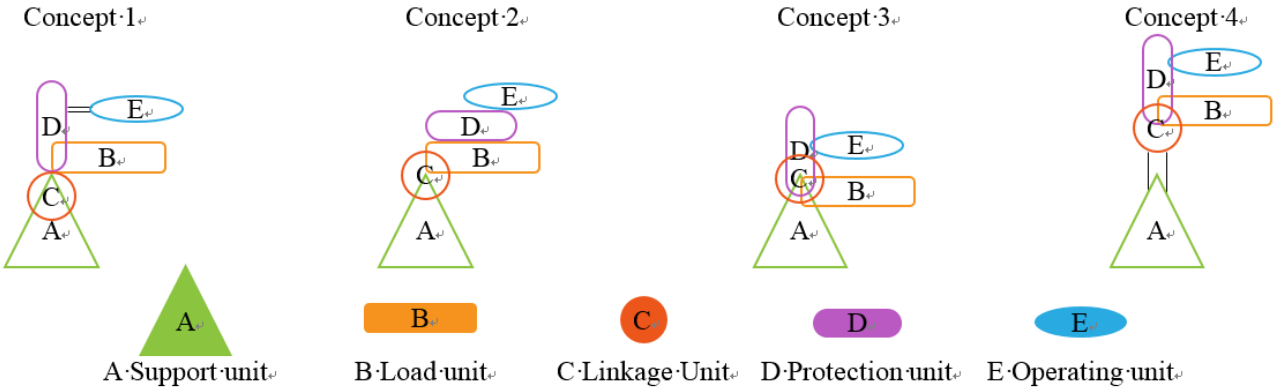

Fig. 3 Spatial layout analysis of highchair

4.3 Innovative Design Based on Function Analysis

This stage aims to further improve the innovation of highchair on the basis of inherited charm factors through functional analysis. First, the functional "black-box" of highchair is converted into "white-box", as shown in figure 2. Then, the main function of highchair is disassembled into 5 secondary function units, including "Support unit", "Load unit", "Linkage unit", "Protection unit"

and "Operating unit", and each secondary function unit is arranged in a reasonable way in space to develop 4 concepts, as shown in figure 3. Finally, 3 conceptual designs are developed by combining the charm factors in the early stage and 4 layout methods, as shown in figure 4. Among them, alternative 1 has the following characteristics: 1) The height can be adjusted; 2) The seat cushion is removable; 3) Double plate, more hygienic; 4) Body collapsible. Alternative 2 has the following characteristics: 1) Stainless steel bracket; 2) Cotton cushion; 3) Body collapsible; 4) The tray is detachable; 5) Children sit down before placing safety rings and plates. Alternative 3 has the following characteristics: 1) Triangular braced; 2) the tray is detachable; 3) Body collapsible; 4) Wood material; 5) Height adjustable; 6) The tray is retractable; 7) Cortical material; 8) Can be used as a regular seat. To sum up, the three alternatives all meet the requirements of "Strong and stable", "Save space", "Seats are comfortable" and "Strong practicality". In addition, through functional analysis, further improve the product innovation, specifically reflected in "Double plate", "The seat cushion is removable", "Children sit down before placing safety rings and plates", "The tray is retractable" and "Can be used as a regular seat".

Fig. 4 Renderings of three design schemes

5. Conclusion

For the products in the mature stage, this paper takes the highchair as a case study, and integrates the evaluation grid method and the function analysis method to improve the design. The evaluation grid method is helpful to extract the charm factor of the existing products, so as to serve as a reference for innovative design. The function analysis method can further improve the creativity of target products through functional black-box and spatial layout analysis. In addition, in-depth interviews with experts can ensure the comprehensiveness and reliability of the information obtained, and quantification theory type Ⅰ can help clarify the importance of each charm factor. The final design of 3 highchairs inherited the charm of the existing products, and some innovation in the function, in line with the requirements of improved design. From the above, the improved design method proposed in this paper is an effective design method, which is not only applicable to the design of highchair, but also to other products.

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