Research on Appearance Design of Outdoor Cabinets Focusing on User's Emotional Experience

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Abstract. The appearance design of products is a complicated issue that concerns multiple factors relating to materials, structures, functions, colors, etc. Product modeling is an important medium for the communication between designers and clients. It is also an effective way to satisfy user's emotional experience. In terms of products' appearance modeling, designers have always been dedicated to the creation based on their own experience, inspirations and techniques. Due to the lack of effective evaluation system, it is difficult to deal with user's emotional experience accurately and effectively.

On the basis of the theory and methodology concerning Kansei engineering and imagery cognition, the paper conducts research on design procedures concerning the extraction and application of characteristic elements of product modality focusing on user's emotional experience. It also achieves the systematic expression of user's emotional experience on the level of imagery cognition, and conducts relevant experiments and analysis aiming to set up the evaluation system focusing on the effective expression of product modeling features. The paper takes the design case of outdoor cabinet as an example. Through the virtual construction of product modeling, the paper conducts analysis of perceptual image based on virtual reality from the perspective of user's emotional experience, thus constructing the model of image descriptions on form elements. It extracts characteristic semanteme influencing users emotional experience by utilizing semantic differential method and principal component analysis, analyzes and summarizes perceptual image factor. It analyzes product form elements by using morphology analyzing method, and finds out the corresponding relationship between perceptual image factor and product form. In order to provide theoretical reference to the form designer, this paper also offers a proposal to the issue of "how to conduct product form design and optimization through perceptual image factor".

Keywords: User's emotion experience · Product design · Kansei · VR · Imagery cognition

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1 Introduction

As market competition is getting increasingly fierce, clients have began to show diversification and individuation in their requirements on product appearances (Zhou 2011). Utilitarian functions or values of products are no longer the most primary factor in user's requirements (Zhou 2011). They attach greater importance to emotional experience. Meeting users' complicated and multiple element individualized requirement, designing the products conforming to users' desire and expectation are a crucial task to product design developer (Zhou 2011). Product form design is a multifactorial complexus, which is connected with various factors, such as structure, function, visual sense, material, color, psychology, etc. (Zhou 2011). For products' form design, designer creates it according to their own experience, inspiration and skill all the time. With the development and change of consumption pattern, the development design thought of current products has switched from technology and function orientated to emotion and experience orientated (Zhou 2011). Because lacking of the effective evaluation system reference, it is difficult to accurately and efficiently respond to users' emotional experience demand.

Therefore, in view of the user needs and expectations, it requires both preliminary qualitative analysis and objective quantitative analysis. Accurately grasping users' emotional demand, hobby and tendency has a very important significance to enterprise wining the market.

2 Research Background

Self-driving tour rises in the United States. At first, people called the weekend driving tour as "Sunday Drive", afterwards, it became "Drive Travel". In 1990s, automobile started to enter in Chinese families. Up to this day, Chinese automobile consumption has transformed from high-end to mass consumption. According to China National Tourism Administration (CNTA) China Self-driving Tour Annual Development Report (2014–2015), the national every hundred households possesses 25 private cars, with the total person of self-driving tour in 2014 being about 2.2 billion.. Chinese self-driving tour industry develops prosperously, and the products sales related to self-driving tour is also in the strong growth (Xiao 2010).

Different from western countries' self-driving tour form of taking estate car as principal, China is high population density, and has a lot of road facility limitations, with urban and rural environment being difficult to meet the parking and driving of travel saloon car (Yu and Wu 2011). Therefore, Chinese self-driving tour mainly gives priority to family small automobile. However, Chinese dining habit is essentially different from foreign dining habit, with a great diversity of Chinese cooking methods. Therefore, it must research the operational method and culture of Chinese dining if we want to meet Chinese dining demand outdoors, developing miniaturization, integration and multifunctional vehicle-mounted outdoor cabinet. The products in this research are exactly researched ad developed under this background (Fig. 1).

Outdoor cabinet is designed for solving outdoor dining problems of self-driving tour users. In addition to provide the necessary table and stool functions, it also

Fig. 1. Outdoor cabinets design

integrates and takes stoves and kitchen utensils and appliance, tableware, tool and others, which makes users can conveniently take it in the trunk of the automobile, unfolding at any time any where, in order to solve the outdoor dinning problem. Therefore, based on fully researching users' demand in emotional experience, aesthetic taste, etc., it designs the truly "heartstrings" products in accordance with users' expectations. On the basis of this objective, designers need to grant products with more emotional factors when they consider the products form.

The perceptual image of products is a kind of mental feelings of people to object and a deep-seated affective activity. It mainly uses the relative theory and methods of Kansei Engineering to research perceptual image (Zhou 2011). Kansei Engineering is a technology combined with sensibility and engineering, which mainly designs products according to people's sentimental demand and manufactures products according to people's habit (Zhou 2011). It quantitatively expresses all feelings (amount of perceptual) of people to object (products, environment, etc.,) through engineering technology means (Zhou 2011). And then, it tries to find out the internal connection between amount of perceptual and the physical quantity (product feature) used in the product design (Zhou 2011). Moreover, it takes this kind of connection as the basis of product's design and development, analysis and research. The research objective of Kansei Engineering is "people", and its serving objective is the design process and object (products) (Zhou 2011). It establishes the logical relation between people and object through a series methods, to help designers to design the "object" which meets the "people's" feeling and expectation.

3 Literature Review

Professor Mituo Nagamachi systematically discussed the effect and application method of Kansei Engineering in product design in Kansei Engineering in Consumer Product Design, which researched people's emotional factors in products. Simmon Schutte further investigated and discussed to the products' emotional problems in Designing

Feelings into Products—Integrating Kansei Engineering Methodology in Product Development, and also researched the emotional engineering research methods at product's developing and designing stage. Norman made an in-depth research to the product's emotional experience in Emotional Design, which has an important significance to product's emotional research. Akinori Takamasa explored vehicle systems in A Kansei Engineering Approach to a Driver/vehicle System by utilizing various Kansei Engineering methods. Rajkumar researched the customer-centered design methods and approaches in User-centric Design and Kansei Engineering by utilizing Kansei Engineering methods. Zhou Meiyu and Dai Guangliang analyzed their relationship through image scale and Kansei Engineering methods in the Yacht Form Imagery Cognitive and Perceptual Design Research, built the model of semantic space and sentimental design, which provided reference basis for product's design. Huang Cheng et al established the mathematical model of styling features and image semantic by utilizing morphological analysis method to extract design elements in Smart Watches Modelling Study Based on Consumer Psychology and Kansei Engineering, thus to accurately grasp consumers' psychological perceptual image. Yao Ziying and Wang Siping found out the principal component factor influencing users' perceptual cognition through factor analysis method in Projector Modeling Design Based on Perceptual Image, and found out the weight factor influencing product's appearance through morphological analysis method, which has reference significance to this research's methods.

In conclusion, the research to users' emotion is an important content to the research of Kansei Engineering. The varied methods application can effectively improve the products form of users' emotional demand. However, it can find that in the current research, the sensibility evaluation to products mainly relies on 2D images, which is relatively week to products' intuitive experience. So, the investigation results' degree of reliability is generally, and its influence to subsequent design research is relatively significant. Therefore, in Kansei Engineering research, "how to improve the experience reliability in research" is a problem demanding prompt solution.

4 Research Methods

4.1 Questionnaire of Combining VR Technology

Questionnaire is a method to collect research objects' research material and data through the strictly designed measuring projects or problems in written form. In consideration of requiring test to get closer to the participants' experience data of real product form to improve the accuracy and reliability of data, this paper's questionnaire survey adopted VR technology platform, which can carry out immersive user experience to the virtual concept form of outdoor cabinet. The G-MAGIC six-channel virtual reality system of ECUST is the domestic leading VR experiential platform. Restoring through cavernous product form, it can intuitively reflex product's future actual shape and functional characteristics. Comparing to plane display device, it possesses a more real and straightforward visual experience, and has reliable supporting effect to users' emotional determination.

4.2 Semantic Differential Method (SD)

SD method is an attitude measurement technology proposed by American psychologist, Osgood, and it is a test method researching participants' mental imagery. SD method takes adjectives as basis, which requires participants to make an evaluation to things or concepts on some measure gauges of opposite meaning. SD method applied to product design shall firstly determine the measure gauge grade of the measured object (product), and generally, it is divided into seven continues grades (Fig. 2). It requires participants to evaluate each attribute according to their feelings and opinions to the measured object, and mark in the corresponding grade position.

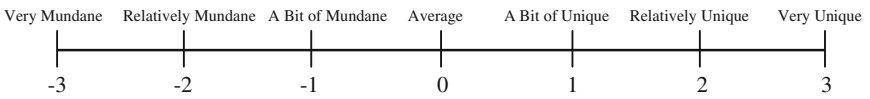


Fig. 2. Semantic difference measure gauge

4.3 Principal Component Analysis Method (PCA)

PCA method is a multivariate statistical method which changes multiple variables into a few aggregate variables. During the research process, in order to comprehensively and systematically analyze problems, it must consider the influence of many factors, but too many variables will increase the problems' complexity degree. Therefore, people hope to get more information with fewer variables. PCA is an ideal method solving this kind of problems. After importing the data extracted through SD method into professional statistical software SPSS, this paper gets the related conclusion through data processing.

4.4 Appearance Analysis Method

The characteristic of Appearance analysis methods is that dividing research objects or questions into some basic components, and then making a separate analysis to a certain basic component. It respectively provides various solutions or methods. In the end, it forms the general plan of the whole problem. Through questionnaire, this paper lists the main factor's score of influencing product's form image, and gets the internal relation of product's each form components through analyzing the factor score between product form samples, then puts forward suggestions to product's form design optimization.

5 Research Process

This paper applies the principles and methods of Kansei Engineering, and combining with the example of outdoor cabinet product design, it researches and reflects the corresponding relation between product form characteristics and users' experience, and then, it extracts morphological characteristic factors of influencing users' psychological

feelings to products. In order to get the relatively reliable data in experiment, it respectively organizes two groups of respondents in this research: Group A and Group B. Group A is constituted by 5 senior product designers and 5 outdoor players; Group B is constituted by 30 industrial design students, 10 personnel of having cooking experience, and 10 personnel of without cooking experience.

5.1 Emotional Semantic Space Establishing Based on VR Technology

Through the relevant information searching to Chinese food and beverage, outdoors dining and self-driving tour dining, and the interview to outdoor players and picnic users, it collects the perceptual image description vocabulary to the modeling and function of outdoor cabinet. Screening and finishing these collected vocabularies, it gets 36 pairs of perceptual vocabulary, and then it builds semantic dictionary. Formulating semantic differences questionnaire, asking the respondents of Group A to carry out subjective judgment. Classifying 36 pairs of perceptual vocabulary and selecting 9 words with highest votes, and combining its corresponding antonym to take it as sample. In the end, it gets 9 pairs of perceptual adjectives (Table 1).

Table 1. Perceptual vocabulary pairs

Vocabulary pair	Code
Complex - Concise	Y1
Retro - Modern	Y2
Normal - Personality	Y3
Decoration - Functional	Y4
Heavy - Light	Y5
Tough - Soft	Y6
Formal - Leisure	Y7
Ugly - Beautiful	Y8
Difficult to clean - Easy to clean	Y9

After extensive research, the outdoor cabinets of similar type in the market are relatively rare. Therefore, this research collected 16 styles of concept outdoor cabinet designed by professional designers as samples. Because of a relative complex product structure, too many components, and being difficult to research with solid model, this research applied G-MAGIC system to carry out product display and experience. In G-MAGIC, combining the virtual 3D products with outdoor environment, it can unfold and operate the real-time product function module, and can fully show product's details (Fig. 3). It makes respondents can experience product's modeling and functions more real, which not only reduces experiment cost, but also improves respondent's experience reliability. All the 16 product samples in this research adopt the unified match colors to reduce the color influence factors. As shown is Fig. 4.

Applying SD method to combine the selected 9 pairs of perceptual image vocabulary with 16 styles of product sample and formulate it into questionnaire. The questionnaire is

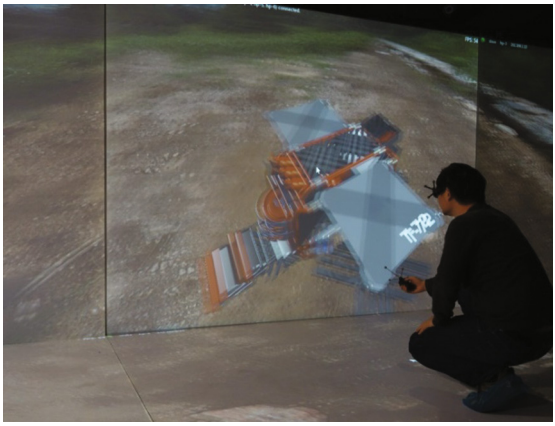


Fig. 3. Using products in G-MAGIC VR system

Fig. 4. Outdoor cabinets design sample

formulated according to seven measure gauges (−3, −2, −1, 0, 1, 2, 3) of SD method. Carrying out G-MAGIC system test by combining the respondents of Group B, and filling in the questionnaire. Carrying out statistics to all questionnaires, Adding the image description evaluation value of the respondents of Group B to product samples together, and averaging it, then it comes the evaluation average value. The results are shown in Table 2.

Table 2. Mean scores of the evaluation

Sample	Vocabulary pair								
	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9
T_1	0.231	0.473	−1.120	0.654	0.213	−1.534	−0.539	−1.612	1.072
T_2	1.191	−0.275	−1.017	1.057	0.222	−1.136	−1.496	−1.664	1.271
T_3	0.015	1.145	1.024	1.312	0.376	0.261	0.453	0.307	0.183
T_4	−0.143	1.514	1.982	−1.183	0.337	1.611	1.322	0.636	−0.567
T_5	0.452	1.276	0.574	−0.435	0.164	1.312	0.373	0.723	1.051
T_6	−0.432	0.741	−1.052	0.726	−0.438	−1.718	−1.283	−1.212	−0.172
T_7	−1.302	1.665	1.317	−0.269	−0.163	0.071	1.275	1.143	−1.203
T_8	−0.527	0.342	−0.715	1.112	−0.249	−0.334	−0.054	1.301	0.130
T_9	0.279	0.413	0.174	−0.214	0.043	−1.682	−0.331	−0.121	0.189
T_{10}	0.306	0.222	0.096	1.203	1.322	0.654	0.358	0.603	0.048
T_{11}	1.874	1.143	0.172	−0.332	1.351	−0.026	1.636	1.236	1.895
T_{12}	−1.175	−0.328	−1.311	0.703	−1.076	−0.836	0.007	−1.732	−0.217
T_{13}	0.442	1.175	−0.667	0.052	−0.737	0.760	0.464	0.923	1.013
T_{14}	0.241	−0.217	0.032	−0.416	−1.411	−1.376	−1.582	−1.875	0.651
T_{15}	0.526	1.251	0.227	−0.541	0.101	0.304	1.104	0.154	0.382
T_{16}	0.213	−0.402	−1.162	0.633	0.238	−0.236	−0.061	−0.173	−0.013

Taking 9 pairs of perceptual image vocabulary as variable Y, carrying out PCA analysis in SPSS, taking factors of its eigenvalues being greater than 1, getting 3 PCA factors of relative great contribution rate, with its cumulative contribution rate being 82.932 %. According to the results outputted by SPSS, it sorts PCA analysis results into Table 3.

Table 3. Results of factor analysis

Factors	Code	Factor load			Eigenvalues	Contribution rate %	Cumulative contribution rate %
Factor1	Y_8	0.896	−0.006	0.061	4.205	46.720	46.720
	Y_7	0.882	−0.034	0.235			
	Y_6	0.814	−0.011	0.221			
Factor 2	Y_1	0.086	0.977	0.030	2.141	23.790	70.510
	Y_9	−0.160	0.937	−0.003			
Factor 3	Y_4	−0.197	−0.072	−0.932	1.118	12.422	82.932

According to the rotated PCA matrix, it is known that high load variables on factor 1 are Y_8, Y_7, Y_6, and it concludes them as style factors according to their perceptual image. The high load variables on factor 2 are Y_1, Y_9, and it concludes them as quality factors. The high load variable on factor 3 is Y_4, and it concludes it as value factor. Figure 5 is three factors rotating space composition three-dimensional diagram. So far, it finds out 6 groups of typical perceptual image vocabulary, as shown in Table 4. It shows that users' perceptual awareness to these vocabularies is relatively high, and these vocabularies represent users' perceptual image to product.

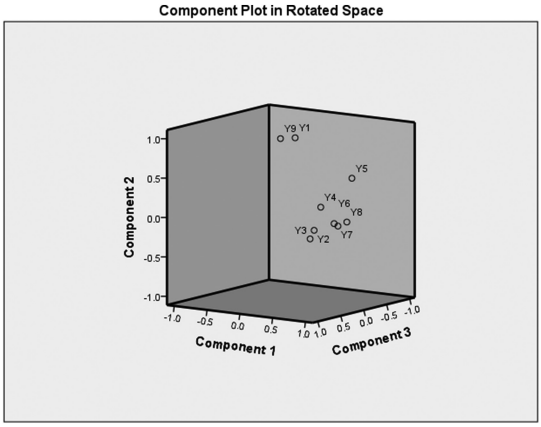


Fig. 5. Component plot in rotated space

Table 4. Typical image vocabulary pairs

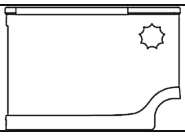
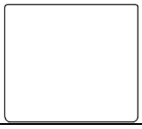
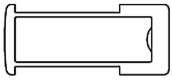
Vocabulary pair	Code
Ugly - Beautiful	Y_8
Formal - Leisure	Y_7
Tough - Soft	Y_6
Complex - Concise	Y_1
Difficult to clean - Easy to clean	Y_9
Decoration - Functional	Y_4

5.2 Appearance Design Analysis

Product form has direct influence to users' image cognition. In order to further grasp the form features of designing scheme, it needs to carry out form elements decomposition to products. Finding out the internal relation between form elements through investigating typical perceptual image factors to users, so that designers can carry out the targeted revise and perfect to the form of product.

Firstly, it investigates the respondents of Group A. It respectively experiences it by aiming at the product form, and determines 5 main products' form elements according to experience investigation results, namely, these five elements are cabinet body, side

Table 5. Product form decomposition questionnaire

Parts	Code	Pic	Y_8	Y_7	Y_6	Y_1	Y_9	Y_4
Main	T_3		Ugly ● ● ● Beautiful	Formal ● ● ● Leisure	Tough ● ● ● Soft	Complex ● ● ● Concise	Difficult to clean ● ● ● Easy to clean	Decoration ● ● ● Functional
Cabinet Body	T_3-a		○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3
Side Panel	T_3-b		○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3
Cover Plate	T_3-c		○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3
Drawer	T_3-d		○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3
Handle	T_3-e		○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3	○-3 ○-2 ○-1 ○ 0 ○ 1 ○ 2 ○ 3

plate, cover plate, drawer, and handle. Because of schedule time limit of investigation work, this research emphatically selects two products of T_3 and T_7 to carry out morphological decomposition research, and it respectively formulates products' form decomposition questionnaire. Taking T_3 as an example, and as shown in Table 5. The respondents of Group B carry out perceptual evaluation scoring, summarize and formulate Table 6.

Analyzing according to the results shown in Table 5: firstly, for style factor, the form separating degree between the side plate of T_3, the form of the drawer and other components is relatively big, which shows that the style difference is obvious. Of course, in consideration of taking the side plate as outdoor table top to design, its form is relatively regular, and we can consider to add the curve line (round form style controlled by Y_6) in later design to improve the consistency of its style; the style consistency of T_7 maintains a relatively consistent. Secondly, for quality factor, the deviation degrees of the cabinet body, cover plate, side plate and handle of T_3 are very

Table 6. Product design form evaluation

Code	T_3					T_7				
	T_3-a	T_3-b	T_3-c	T_3-d	T_3-e	T_7-a	T_7-b	T_7-c	T_7-d	T_7-e
Y_8	0.131	0.207	0.026	−0.122	0.410	1.673	1.416	1.101	0.733	0.213
Y_7	1.051	−0.778	0.141	−0.357	1.021	0.878	1.158	1.483	1.207	−0.035
Y_6	0.532	0.021	0.172	−0.655	1.123	0.113	0.352	−1.660	−1.701	0.342
Factor 1(∑)	**1.714**	**−0.55**	**0.339**	**−1.134**	**2.554**	**2.664**	**2.926**	**0.924**	**0.239**	**0.520**
Y_1	−1.301	1.863	−1.516	−0.584	1.725	−1.833	−0.144	−0.707	−0.832	−1.522
Y_9	−1.015	2.031	−0.363	1.301	−0.210	−1.905	−0.463	−2.215	−2.228	−0.317
Factor 2(∑)	**−2.316**	**3.894**	**−1.879**	**0.717**	**1.515**	**−3.738**	**−0.607**	**−2.922**	**−3.06**	**−1.839**
Y_4/Factor 3	**−1.037**	**1.603**	**−0.470**	**−1.204**	**−0.873**	**−1.851**	**−1.078**	**−2.011**	**−1.870**	**−0.331**

significant, which shows that quality contrast is relatively obvious; the quality consistency of each component of T_7 is relatively balanced, however, the orientation is negative, which shows that on the whole, the design quality is unsatisfactory. Last, for value factor, two styles of design scheme do not show the obvious practical characteristics, meanwhile, it also shows the next step's improvement direction.

6 Summary and Discussion

Introducing VR technology in users' emotional experience research is a creative attempt. With the help of Kansei Engineering research method, it can carry out quantitative and qualitative analysis and improvement to the image form of design scheme. Because the samples in this research are still the conceptual products, users' perceptual knowledge to it is still relatively unfamiliar. It still has form and function misunderstanding in experience, therefore, at a certain degree, it influences the statistical result. It still needs to further sort and develop the operation mode of Chinese food and beverage and the tool function research. It also needs to further increase the quantity of samples, and further refine and separate the components of sample form analysis. In the future, we can consider to carry out comparative and analytic research to the added new improved design scheme and the early design scheme. All of these are the problems which need to be solved in the subsequent research.

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