Design Studies and Intelligence Engineering
L.C. Jain et al. (Eds.)
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doi:10.3233/FAIA220732

Research on the Design of Home Lighting E-Commerce Platform Based on Kano-QFD Method

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Abstract. First of all, the actual needs of users are deeply explored through in-depth interviews with actual buyers of home lamps and lanterns, and discussions with senior experts in the industry, and simultaneously collected the three representative home lighting e -commerce platform products on the three markets for experience analysis, and finally fused information to form actual demand; secondly, the priority of needs are analyzed qualitatively based on the Kano model from two dimensions of user satisfaction and the importance of needs, and the importance of design needs are analyzed and quantified through QFD quality function diagram. Results: A priority sorting of the importance of the function of the family lighting network platform. Then the framework construction of the e -commerce platform and design practice are based on the user's front, middle and back operation habits of the home lighting e -commerce platform. Conclusion: We have further optimized the functionality and adaptability of the lamp e -commerce platform, and completed the construction and practice of the functional architecture of home lighting system based on design elements and relative importance interface design principles which provides theoretical value and practical reference for the construction and design practice of the same type of system.
Keywords. Kano-QFD method**,** User Experience**,** Home Lighting, E-commerce platform

1. Introduction

With the introduction of "Made in China 2025", the continuous integration of manufacturing and Internet development has brought new opportunities for the transformation of household products [1]. The e-commerce platform performs flat management on the production, procurement and sales chain The factory directly supplies to offline retail terminals, reducing logistics and operating costs, and truly realizing efficient supply chain docking. E-commerce platform will be the main way of home lighting now and in the future.

Through the existing operating home lighting e-commerce platform for collection and research, can be roughly summarized as the following four categories, as shown in the figure; (1) brand online self-owned platform, such as Philips lamps and lanterns product line shopping platform (see Fig 1); (2) brand stationed in a comprehensive e-commerce platform, such as home lighting Tmall flagship store, Tik Tok flagship store platform (see Fig 2); (3) Brand promotion and sales by way of the exhibition platform, China's Zhongshan Guzhen is an industrial cluster of lamps and lanterns processing and manufacturing (see Fig 3); (4) lamps and lanterns vertical e-commerce platform, with targeted business independent App, mini program, etc. (see Fig 4).

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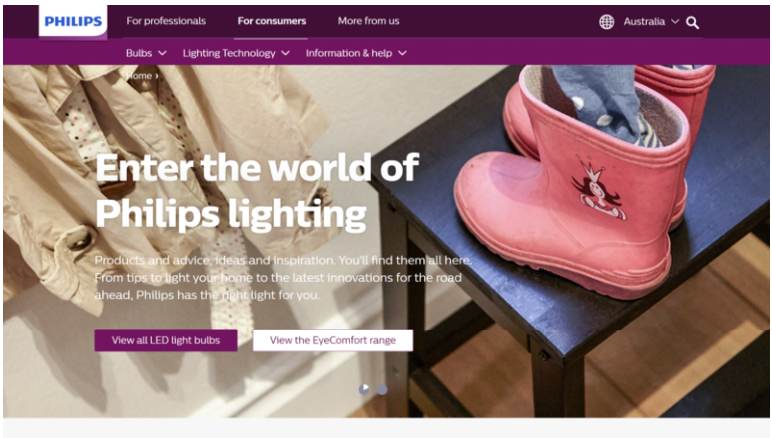

Figure 1. Brand E-commerce.

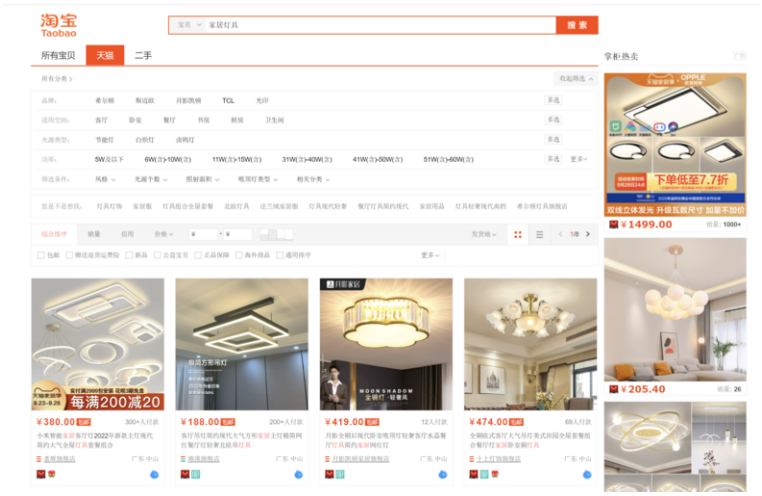

Figure 2. Tmall flagship store.

Figure 3. Exhibition platform.

Figure 4. Mini program.

Once e-commerce was introduced, it brought a significant impact on the traditional marketing model, and a large number of physical stores in many industries disappeared under the impact of e-commerce, and the marketing model was essentially changed [2]. Because the e-commerce platform is very convenient, the use of its target scenario is the user's home, so "home delivery" for home lighting is clearly more advantageous way. Most home lighting companies usually show their products to buyers by way of an online platform, and buyers only judge and place orders through some visual effect pages provided by the sellers, and then the products can be delivered to their homes through logistics and other means.

However, through practical interviews, it was learned that while e-commerce platforms bring so-called convenience to users, they also bring some other problems accordingly.

Question one, generally most of the conventional products, in the user through the online channel for procurement can be through certain conditions, such as: form, material, function, parameters and other factors for accurate evaluation and decision-making before purchase， but due to the very special nature of lighting products, buyers are not able to fully understand the product through the online experience. Only the buyers (users) can get the feeling of the product and make a judgment of suitability only after

touching the actual luminaire product or getting further immersion experience. It is clear from the interviews that buyers are not able to fully and perfectly understand the product only by way of online product pictures, which can still cause a mismatch between the product and the consumer's expectations.

Question two, although some platforms to the user to return or exchange and other compensation through the form of transport insurance, but the structure of household lighting products is relatively fragile compared to ordinary home appliances, the complicated transportation and return process not only causes an increase in the rate of product damage, the intermediate transportation wastes economic costs and human energy, but also cannot achieve the purpose of using the product to the satisfaction of the user.

Question three, with the progress of society, the level of production and supply channels to increase the current variety of complex lighting products, product categories are a wide range of prices from a few tens of dollars to several hundred dollars products are present [3]. Such diverse prices in today's market and more choices for users also reveal a kind of bewilderment, because only through the superficial product display information, still cannot solve the unique brightness, atmosphere, environmental matching and other problems of home lighting. Due to the lack of in-depth analysis of consumer preferences and user needs, the web design of e-commerce platforms is characterized by a large amount of disorderly and ineffective information piling, which not only has a great negative impact on users' browsing and purchasing experience, but also greatly weakens the marketing effect of e-commerce brands [4].

Therefore, although the current view of online sales of lamps and lanterns compared with offline sales methods is progress, but from a more complete purchase experience and more humane user shopping process, there is still a period of progress in the space. These issues are the core problems that need to be solved in the design of the lighting e-commerce platform.

First of all, this paper summarizes and analyzes the use and experience of the representative home lighting e-commerce platform in the early stage, as well as combining the interview data of the audience groups and senior service design practitioners of the e-commerce platform, and then extracts the key words from them to summarize them as user needs. Secondly，based on the Kano model, the requirements of target users are differentiated qualitatively and by type to obtain the importance of requirements. . Then, the requirements are quantitatively transformed into functional importance by constructing QFD quality house. Finally, the hierarchical analysis was translated into visual interface design. This combination of qualitative and quantitative approaches effectively ensures that the designers involved are not biased by the subjectivity of the problem. It is worth noting that all user requirements upfront require the designer's attention, but in practice are limited by resources and must be prioritized to meet the more important requirements. In this paper, the authors explore only slightly at the level of design methods, but the trade-offs are a long-term process.

In this paper, we conduct actual research on the selling platform of lighting e-commerce and online users, use Kano model to analyze the user requirements of furniture e-commerce platform, and then get the QFD function priority table to optimize some functions to provide users with better online selling mode and provide consumers with better and more thoughtful shopping experience.

2. Explanation of the Kano-QFD Method

The Kano model is proposed by Noriaki Kano, a Japanese scholar. The model reflects the relationship between product performance and user satisfaction. It is widely used in many fields. In the design field, it helps designers to sort user needs and thereby improve products and user experience in a targeted manner. To better translate user needs into functional requirements, QFD is introduced to quantify the ratio of user needs to product features. On such a basis, Matzler and Hinter huber proposed a method integrating the Kano model and QFD in 1998 [5]. On top of their research, Duan Liming proposed an improved algorithm to enhance the accuracy of the measurement [6]: first, collect user requirements through questionnaires, interviews, etc., then work out the weights of the requirements based on the Kano model, and form the matrix of user requirements and functional requirements, in the end, obtain the weights and order of functional requirements. This paper adopts this method to further analyze user requirements.

3. Research on the design process of home lighting e-commerce platform based on Kano-QFD method

Since the home lighting e-commerce platform is mostly a platform for consumers to buy lamps and lanterns for their household needs, the customers it serves are a wide range of mass consumption groups. Therefore, the user group studied in this platform is for all users who have the ability to complete the Internet shopping behavior independently [7].

3.1. User Requirement Elicitation

To further identify user needs, on top of those collected from the questionnaire survey, in-depth interviews were given to target users. Nielsen pointed out in the re-search on user experience that, 80% of the problems were identified by testing 5 users on average [8] .

In this paper, six practitioners who are still engaged in luminaire platform operation and selling related and two UX industry experts and one live marketer were selected for in-depth interviews. By interpreting the original interview text, and sorting out words and sentences of the same meaning, the user needs were eventually summarized (see Table 1).

Table 1. User requirements table.

Level 1 Requirement (R)	Level 2 Requirement (S)
R_1 Browse and filter home lighting	S_1 Lighting products are pushed according to lighting categories and home decoration styles. S_2 lighting products are pushed according to brand categories. S_3 New product push based on new releases S_4 Lighting products are sorted and pushed according to classic design celebrity design models. S_5 Energy saving and environmental protection lamps and lanterns list S_6 Crowdfunding creative new lamps and lanterns S_7 Guess what you like

R_2 Home lighting presentation	S_8 Provide 3D simulation for intuitive lighting scene arrangement and matching. S_9 Visualize the energy efficiency and durability of the luminaire, etc. S_{10} Visualize the brightness, warmth and coolness of the light.
R_3 Goodies recommendation and sharing	S_{11} Home Lighting Community Forum (e.g. Recommend & Share) S_{12} Professional blogger lights provide with home scenes with the strategies. S_{13} Provide freedom for users to rate products after purchase (e.g., multiple follow-up reviews, etc.)
R_4 Purchase method	S_{14} Design story behind the designers S_{15} Place a purchase order S_{16} Daily Specials \ Discount Group Purchase
R_5 Personal Center	S_{17} View Historical Footprints S_{18} Favorites and Collections S_{19} Shopping cart S_{20} All order information \ Logistics S_{21} Personal information S_{22} Contact Customer Service

3.2. Analysis of interaction requirements for lighting e-commerce platforms

Kano Questionnaire Analysis.

The Kano questionnaire here includes 20 secondary needs from the previous sec-tion as the questions to determine the users' attitudes toward each need [9]. Their specific feelings are described as five levels: very dissatisfied (1 point), dissatisfied (2 points), indifferent (3 points), satisfied (4 points), and very satisfied (5 points). Through pre-liminary analysis, this questionnaire survey included professionals with experience in medical emergency rescue. To enhance the accuracy of the survey and facilitate the interviews, the questionnaires were distributed offline. A total of 90 questionnaires were collected, of which 86 were valid. The obtained Kano questionnaire data were tested for reliability and validity. Generally, if Cronbach's alpha is above 0.8, the questionnaire data are considered highly reliable. The validity, on the other hand, is measured by KMO and Bartlett's test—KMO> 0 and p in Bartlett's test< 0.05 indicate that the research data are great for extracting information.

The questionnaire data were imported to SPSS for analysis. The obtained Cronbach's α for forward problems was 0.951, and that for reverse problems, 0.888. KMO of forward problems was 0.903, p=0.000; KMO of reverse questions was 0.851, p=0.000. Therefore, the questionnaire is of good reliability and validity, and very suitable for extracting information.

Kano User Requirement Analysis.

The collected questionnaire data were then analyzed statistically. According to the table of Kano model scores (see Table 2), the attribute of each requirement was obtained.

In the table, A = Attractive, O = One-dimensional, M = Must-be, I = Indifferent, R = Reflected, and Q = Question.

Percentages of A, O, M and I in a requirement were worked out:

$$X_i = \frac{A_i + O_i}{A_i + O_i + M_i + I_i} \tag{1}$$

$$Y_i = \frac{O_i + M_i}{A_i + O_i + M_i + I_i} \tag{2}$$

Here: X_i is the increase of user satisfaction with this requirement met; Y_i is the decline in user satisfaction when this requirement is not met. Therefore, the relative weight w_i of each secondary requirement is:

$$w_i = max\left(\frac{X_i}{\sum_{i=1}^{n} X_i}, \frac{|Y_i|}{\sum_{i=1}^{n} |Y_i|}\right) \tag{3}$$

Here, i=1, 2, …, n, n being the number of secondary requirements.

X_i, Y_i and the relative weight w_i of each requirement were obtained from formulas (3-1), (3-2) and (3-3), as well as the attribute and weight of each requirement, see Table 3 in the Appendix.

The weight and attributes of each requirement were worked out.There are four essential requirements (M), four charismatic requirements (A), six expectation requirements (O), and the remaining eight non-differentiated requirements (I), which can be met according to specific functional settings as appropriate.

Table 2. Kano model comparison table.

		Negative topics				
	Function/ Service	Very unsatisfied (1score)	Unsatisfied (2score)	Indifferent (3score)	Satisfied (4score)	Very satisfied (5score)
Positive topics	Very unsatisfied (1score)	Q	R	R	R	R
	Unsatisfied(1score)	M	I	I	I	R
	Indifferent(1score)	M	I	I	I	R
	Satisfied (1score)	M	I	I	I	R
	Very satisfied(1score)	O	A	A	A	Q

Table 3. Attributes and weights of requirements table

Level 2 Requirement（S）	A	O	M	I	X_i	Y_i	w_i	Attribute
S_1 Lighting products are pushed according to lighting categories and home decoration styles.	18	26	16	26	0.51163	-0.48837	0.040	O
S_2 lighting products are pushed according to brand categories.	14	24	23	25	0.44186	-0.54651	0.045	I
S_3 New product push based on new releases	23	20	11	32	0.50000	-0.36047	0.039	I
S_4 Lighting products are sorted and pushed according to classic design celebrity design models.	49	21	3	13	0.81395	-0.27907	0.064	A
S_5 Energy saving and environmental protection lamps and lanterns list	48	32	1	5	0.93023	-0.38372	0.073	A
S_6 Crowdfunding creative new lamps and lanterns	24	19	0	43	0.50000	-0.22093	0.039	I
S_7 Guess what you like	14	23	0	49	0.43023	-0.26744	0.034	I
S_8 Provide 3D simulation for intuitive lighting scene arrangement and matching.	48	32	0	6	0.93023	-0.37209	0.073	A

S_9 Visualize the energy efficiency and durability of the luminaire, etc.	10	67	5	4	0.89535	-0.83721	0.070	O
S_{10} Visualize the brightness, warmth and coolness of the light.	8	67	5	6	0.87209	-0.83721	0.069	O
S_{11} Home Lighting Community Forum (e.g. Recommend & Share)	13	22	0	51	0.40698	-0.25581	0.032	I
S_{12} Professional blogger lights provide with home scenes with the strategies.	16	27	0	43	0.50000	-0.31395	0.039	I
S_{13} Provide freedom for users to rate products after purchase (e.g., multiple follow-up reviews, etc.)	10	28	29	19	0.44186	-0.66279	0.055	M
S_{14} Design story behind the designers	46	26	0	14	0.83721	-0.30233	0.066	A
S_{15} Place a purchase order	2	37	40	7	0.45349	-0.89535	0.074	M
S_{16} Daily Specials \ Discount Group Purchase	9	36	4	37	0.52326	-0.46512	0.041	I
S_{17} View Historical Footprints	5	28	34	19	0.38372	-0.72093	0.060	M
S_{18} Favorites and Collections	7	27	7	45	0.39535	-0.39535	0.033	I
S_{19} Shopping cart	4	34	39	9	0.44186	-0.84884	0.070	M
S_{20} All order information \ Logistics	4	40	36	6	0.51163	-0.88372	0.073	O
S_{21} Personal information	1	38	33	14	0.45349	-0.82558	0.068	O
S_{22} Contact Customer Service	3	43	39	1	0.53488	-0.95349	0.079	O

3.3. QFD-based Functional Transformation and Sorting

Building the Mapping between User Requirements and Design Elements

With QFD, the user secondary requirements summarized may be converted into functional requirements; meanwhile, the priority of the functions was analyzed quantitatively [10]. First of all, the functional requirements to meet the user requirements were obtained based on the mapping of user requirements, see Table 4 in the Appendix. Functional transformation of user requirements by using the mapping ensured the rationality of the functional requirements. Realizability decomposition of the requirements guaranteed maximum functionality while meeting user requirements.

House of Quality and Priority of Design Elements

Next, a panel of three experts rated the relevance of the functional requirements to user needs. The scores were 0, 1, 3, 5, representing no relevance, weak relevance, relevance, and strong relevance.

On such a basis, the matrix of the relationship between user needs and functional requirements was obtained, see Table 5.

The weight of each functional requirement was worked out:

$$R_j = \sum_{i=1}^{n} w_i r_{ij} \tag{4}$$

Here, r_ij is the coefficient of relevance between the ith user need and the jth functional requirement, j=1, 2, …, m, m being the number of functional requirements. The obtained weights and order of functional requirements are seeing Table 6. The

weights of the functional requirements R_j were ranked to reveal their level of importance. The results are seeing Table 7 in the Appendix. The priority of the functions obtained from the table provides a reference for the architecture of the home lighting e-commerce platform based. It also provides feasible plans for the visualized display of the system. For details of the system's design interface (see Fig 5).

Table 4. Functional requirements table

Level 2 Requirement（S）	Functions (F)
S_1 Lighting products are pushed according to lighting categories and home decoration styles. S_2 lighting products are pushed according to brand categories. S_3 New product push based on new releases S_4 Lighting products are sorted and pushed according to classic design celebrity design models. S_5 Energy saving and environmental protection lamps and lanterns list S_6 Crowdfunding creative new lamps and lanterns S_7 Guess what you like	F_1 Menu push function for lighting styles, categories, brands and new products F_2 List functions for energy-saving lamps and lanterns F_3 Menu functions for classic design models F_4 Menu functions for crowdfunding new products F_5 Big data intelligent push service F_6 Functions for AR home reality building
S_8 Provide 3D simulation for intuitive lighting scene arrangement and matching. S_9 Visualize the energy efficiency and durability of the luminaire, etc. S_{10} Visualize the brightness, warmth and coolness of the light.	F_7 Functions for home lighting intuitive experience (e.g., lighting brightness adjustment, cooling and heating adjustment) F_8 Functions for home lighting maintenance science (e.g., lighting energy efficiency, lighting durability, lighting maintenance)
S_{11} Home Lighting Community Forum (e.g. Recommend & Share) S_{12} Professional blogger lights provide with home scenes with the strategies. S_{13} Provide freedom for users to rate products after purchase (e.g., multiple follow-up reviews, etc.) S_{14} Design story behind the designers S_{15} Place a purchase order S_{16} Daily Specials \ Discount Group Purchase S_{17} View Historical Footprints S_{18} Favorites and Collections S_{19} Shopping cart S_{20} All order information \ Logistics S_{21} Personal information S_{22} Contact Customer Service	F_9 Functions for home lighting sharing (users, experts, bloggers, designers) F_{10} Functions for User multi-stage evaluation F_{11} Product design stories, designer recommendations F_{12} Functions for discounting and ordering F_{13} My personal information F_{14} Order service information (footprint, favorite, shopping cart, favorite, order, logistics) F_{15} Online Customer Service

Table 5. Matrix of user requirements and functions

Level2 Requirement（S）		Functions (F)														
R	Wi	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}	F_{13}	F_{14}	F_{15}
S_1	0.040	5	1	1	0	3	0	1	1	0	0	0	0	1	1	1
S_2	0.045	5	1	1	0	3	0	1	1	0	0	0	0	1	1	1
S_3	0.039	5	0	0	3	3	0	1	1	3	0	1	1	1	1	1
S_4	0.064	3	0	5	0	3	0	0	1	3	0	5	1	1	1	1
S_5	0.073	3	5	0	0	3	0	3	5	3	0	3	1	1	1	1
S_6	0.039	1	0	0	5	3	0	0	0	3	0	5	3	1	1	1
S_7	0.034	1	1	1	1	5	0	0	1	1	1	1	3	5	1	1
S_8	0.073	1	1	1	1	0	5	3	0	0	3	0	1	0	0	1
S_9	0.070	1	3	0	0	0	5	3	5	1	3	1	1	0	0	1

S_{10}	0.069	1	0	0	0	0	5	5	1	1	3	1	1	0	0	1
S_{11}	0.032	0	0	0	0	3	3	1	1	5	3	3	3	1	1	1
S_{12}	0.039	0	0	0	0	3	3	1	1	5	3	3	3	1	1	1
S_{13}	0.055	1	0	0	0	3	0	0	1	0	5	1	3	3	3	3
S_{14}	0.066	1	1	3	3	0	0	3	3	3	1	5	3	0	1	0
S_{15}	0.074	1	0	0	1	0	1	1	1	1	1	1	5	0	5	3
S_{16}	0.041	1	0	0	0	0	0	0	0	1	0	0	5	0	5	3
S_{17}	0.060	1	1	1	1	3	1	1	1	0	1	1	1	3	5	1
S_{18}	0.033	3	1	1	0	3	1	1	1	0	0	3	3	3	5	0
S_{19}	0.070	3	1	1	1	3	1	1	1	1	0	0	3	1	5	0
S_{20}	0.073	1	1	1	1	3	1	0	0	0	3	0	3	3	5	3
S_{21}	0.068	1	1	1	1	3	0	0	0	0	3	0	3	3	3	3
S_{22}	0.079	1	1	1	1	0	0	1	1	1	5	1	3	0	0	5

Table 6. Function weighting table

F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}	F_{12}	F_{13}	F_{14}	F_{15}
2.141	1.216	1.093	1.041	2.36	1.583	1.702	1.646	1.635	2.176	1.856	2.787	1.478	2.595	2.005

Table 7. Function sorting table

No.	Functions	No.	Functions
1	Functions for discounting and ordering	9	Functions for home lighting maintenance science (e.g., lighting energy efficiency, lighting durability, lighting maintenance)
2	Design story behind the designers	10	Functions for home lighting sharing (users, experts, bloggers, designers)
3	Big data intelligent push service	11	Functions for AR home reality building
4	Functions for User multi-stage evaluation	12	My personal information
5	Menu push function for lighting styles, categories, brands and new products	13	List functions for energy-saving lamps and lanterns
6	Online Customer Service	14	Menu functions for classic design models
7	Product design stories, designer recommendations	15	Menu functions for crowdfunding new products
8	Functions for home lighting intuitive experience (e.g., lighting brightness adjustment, cooling and heating adjustment)		

4. Conclusion

In this paper, the actual needs and potential opportunity points were discovered in the preliminary research on the online e-commerce platform system of home lighting, as well as in the interviews with e-commerce traders, designers and consumers respectively, and further qualitative and typological differentiation of the needs of the target users based on the Kano model to obtain the importance of the needs. In the end, it is converted into visual interface design through hierarchical analysis. Such a qualitative-quantitative method effectively avoids the subjective bias held by the relevant designers. It should also be noted that all preliminary user requirements require the attention of designers; but in practice, limited by resources, the priority must be given to more important requirements. This paper only briefly discusses the design method. The priorities are to be further studied over a long period.

4.1. Limitations

First, in terms of extracting user demands for e-commerce platforms, in terms of research on existing e-commerce platforms, there is no more refined classification of lamps and lanterns e-commerce platforms for further refinement due to manpower constraints. Secondly, the sample size can be further expanded to achieve a more convincing and accurate demand when the demand extraction is carried out by using questionnaires to actual users. Finally, when using the Kano method for listing and summarizing the requirements, only two levels (primary requirements, secondary requirements) were divided, and a more detailed classification would have further improved the accuracy of the results.

4.2. Future work

First, more researchers will be organized to conduct more in-depth research on the online home e-commerce platform, as well as more detailed classification. Not only help the entire category of demands, but also for a specific category of lighting e-commerce platform to put forward a special improvement program.

Second, this study will be ongoing, and in the near future the group will change its working address and be in a position to organize more questionnaires and interviews with users, experiencers and senior personnel to conduct sample size expansion and improve the accuracy of the product results.

Third, to improve the classification accuracy of requirements, through the three-level classification or four-level classification, can be more detailed to reflect the requirements, in the subsequent docking QFD method, it can be transformed into more specific functional items to help the platform system to further enhance and improve.

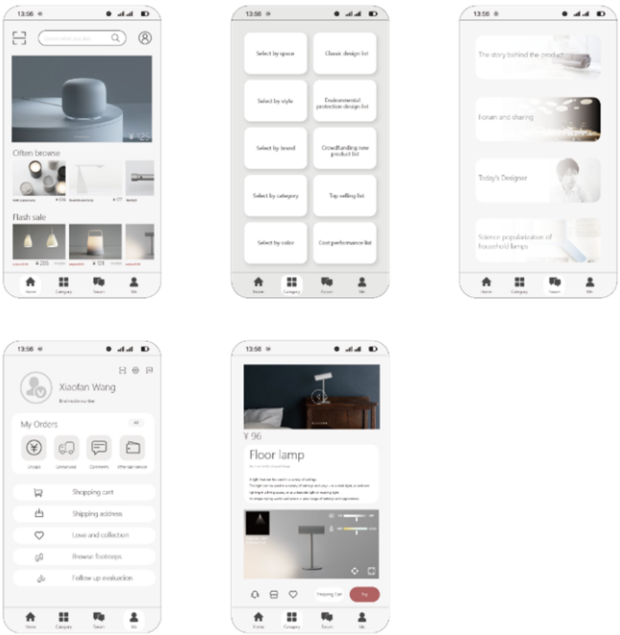

Figure 5. System's design interface.

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