Research on UX Evaluation Model of Computer Input Devices (Keyboard and Mouse) Based on AHP

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Abstract. With the rapid development of the Internet, there are more and more computer input devices for different usage scenarios, and a lot of factors need to be considered comprehensively when users select computer input devices. At present, there are still some problems need to be solved in this field: how to evaluate the user experience of computer input devices in order to give reasonable suggestions to consumers when making purchasing decisions; how can design and development personnel find the shortcomings of design solutions in the design decision process? Aiming at the above problems, a user experience evaluation system for computer input devices is proposed.

Firstly, based on the user experience 5E model proposed by Whitney Quesenbury, the user experience evaluation system of computer input device was constructed by using the questionnaire method, interview method, and expert opinion method. Then, the user experience evaluation model of computer input device was constructed by AHP.

This paper takes computer input equipment as the research object and studies the user experience evaluation method of computer input device through the combination of qualitative and quantitative research methods. Established a more scientific user experience evaluation system to guide the design and development personnel in the design decision process. And provides reasonable suggestions for consumers to purchase and has certain reference value in the field of user experience evaluation research.

1. Introduction

1.1 Research object

The main research object of this paper is the computer input device (keyboard and mouse). The computer input device inputs data and information to the computer and is the main device for information exchange between the user and the computer system. Keyboard and mouse are indispensable computer input devices, and user usage frequency are the highest in all computer input devices, with certain representativeness and research value. This paper will mainly establish user experience evaluation model for keyboard and mouse.

1.2 Research problems

In the field of academic research, the research on user experience evaluation model is mainly for internet products, such as mobile APP, website, system, software etc. But relatively few researches on hardware devices. This paper focuses on the equipment for information exchange between hardware and software. The evaluation criteria include both the hardware experience and the experience of
software. The research object has certain representativeness and research value. The existing user experience evaluations on keyboards and mice are mostly evaluations and purchase evaluations on the web. These evaluations cover different content and no uniform standard. It is difficult to bring a systematic reference to design developers or potential consumers.

2. Establishment of UX evaluation system

2.1 Establishment of criteria level evaluation index
User experience professor Whitney Quesenbery proposed the user experience 5E evaluation model, which includes five aspects: Engaging, Easy to learn, Effective, Error tolerant and Efficient. Since the original 5E model is more concerned with the user experience of Internet products such as software and websites, some of the indicators may not be suitable for hardware products. Therefore, according to the original model content, considering the characteristics of the hardware products, the description of the indicators of the 5E model has been modified to some extent [Table 1].

| 5E Model | Description | Contents |
|----------|-------------|----------|
| Engaging | Good-looking and easy to use, giving users a pleasant experience | Satisfaction |
| Error tolerant | Prevent errors | Error tolerant |
| Easy to learn | There is no obstacle to initial use and deeper use | Easy to learn |
| Efficient | Basic features available | Efficient |
| Effective | Additional features help increasing efficiency | Effective |

2.2 Establishment of alternatives level evaluation indicators
When selecting the user interview sample, the consumers with the purchase intention are mainly selected. In order to avoid the subjective bias caused by the understanding of the keyboard and mouse, and to improve the applicability and persuasiveness of the research results, 4 industrial designers, 1 self-media writer, 2 computer game players are selected as interview sample.

Due to the diversification of keyboards and mice on the market, consumers have different motivations when purchasing products. In order to make the research results more scientific and objective, according to different motivations, three different representative products are selected [Table 2]. Reference equipment for interviews. First, through the completion of specific tasks [2], the user can form a subjective cognition of the keyboard and mouse experience, and then conduct in-depth interviews [Figure 1]. The interview form is a preliminary conclusion to evaluate the evaluation indexes of the keyboard and mouse through direct inquiry.

| Motivation       | Using scenarios | Usage time | Keyboard      | Mouse      | Connection method |
|------------------|-----------------|------------|---------------|------------|-------------------|
| Gaming           | Playing games   | 2-3h       | Dareu First   | Razer      | Cable             |
| Working          | Writing         | 3-5h       | Logitech K380 | Logitech M590 | Bluetooth         |
| Personalized     | Personalized experiences | 1-2h | Hangshi HB066 | Microsoft Sculpt Ergonomic | Bluetooth |
Through classification and integration, a total of 41 indicators were obtained [Table 3].

Table 3. Descriptions of 5E model for computer input devices (keyboard and mouse)

|       |                                                                                           |
|-------|-------------------------------------------------------------------------------------------|
| **Satisfaction** | Color, Material, Shape, Desktop appearance uniform, Surface curvature, Wrist placement, Arm opening width, Keyboard width, Keyboard placement, Product size, Palm, Roller noise, Case noise, The comfort of the feedback sound, The length of the keystroke, Product weight, The moderate force required for the button, The friction of the material, The softness of the material. |
| **Error tolerant** | Keyboard button shape, Keyboard button size, Mouse movement sensitivity, Keyboard button layout. |
| **Easy to learn** | Unique interaction, Easy to understand interactive way, Fast connection to the computer, Easy to learn additional features. |
| **Efficient** | Length of cable, Material of cable, Stability of bluetooth, USB transmission stability, Basic function available, Surface wear resistance, Connection stability, Button usage life. |
| **Effective** | Multi-device adaptation, Multiple additional functions, Adjustable sensitivity, Smooth use, Product portability, High-efficiency combination keys, Wheel flexibility, Connection speed. |

2.3 First round indicator screening

There are many user experience evaluation indicators obtained through interviews, but indicators including repeated meanings, such as Color and Material can be combined into appearances, which also include indicators that may occur for specific scenarios, such as different connection methods. With a mouse, using a wired connection may not require consideration of the ease of connection. Using a wireless connection (such as Bluetooth) requires learning how to connect the product. The basis of the screening is mainly to merge, eliminate and correct the indicators with repeated meanings, superfluous or unclear levels [3], [4], [5]. According to the analysis and screening, the results of the first indicator screening resulted in a total of 19 indicator indicators.

2.4 Second round indicator screening

In order to further improve the objectivity and effectiveness of the indicators, this study organized an expert opinion group to score and screen the indicators. In order to achieve better accuracy, the study identified the number of experts as 10 people, including industrial designers, master students in user experience, and professors in industrial design. The expert opinion method uses the form of scores and in-depth interviews to screen the above indicators.

The expert opinion review in this paper uses the Likert five-point scale to measure the indicators, mainly for the reasonable setting of the indicators. The rating is: completely unreasonable, unreasonable, neutral, reasonable, and completely reasonable.

According to the results of the expert opinion method, the indicators were screened for the second time. The principles of screening were as follows: 1. User experience characteristics of computer input devices (keyboard and mouse); 2. Indicators need to be related to user experience theory; The indicator description language is easy to understand; 4. The indicator meaning is clearly expressed; 5. The indicators with the same meaning are merged; 6. The missing indicators should be added. Based
on the above principles, after discussion and research with experts. Five criteria-level indicators were retained, and 17 alternatives-level indicators were revised and derived.

The satisfaction level has covered the visual experience, the auditory experience, the tactile experience and the human-machine experience. It can fully summarize the user experience evaluation of computer input devices (keyboard and mouse).

At the Error tolerant level, since the size and shape of the buttons may affect the occurrence of wrong clicks, the indicator is corrected to be “Button shape and size are easy to click”. The “Button layout” is corrected to “Button layout conforms to the usage habits”.

At the level of Easy to learn, users usually have a deeper understanding of the keyboard and mouse. Therefore, the easy-to-learn is usually reflected in the additional functions provided by the product. The indicator of “Additional functions are easy to learn” has already been representative.

At the Effective level, the meanings of the two indicators on the connection method are duplicated. The “Stable and effective connection method” is deleted, and the “Connection stability” is retained. Correct the "Lifetime" to "Long product life".

At the Efficient level, because the additional functions of the keyboard and mouse tend to bring efficiency, it is very important for users to use these attachment functions more simply, and the additional feature diversity may only make the product function more complicated. So, correct the "Additional functional diversity" to "Function buttons that simplify operation".

2.5 Questionnaires
In order to improve the practicability and scientific of the evaluation indicators, this paper will reorganize the evaluation system after the expert review and revision into a questionnaire to quantify the form of scoring, and finalize the screening of the indicators to finally determine the computer input device (keyboard and Mouse) user experience evaluation system. The method used in the sample data is the questionnaire survey method, which collects the data needed for the research by widely distributing the questionnaire.

The survey period was 3 days, a total of 241 questionnaires were issued, and 176 valid questionnaires met the data sample size requirements of the Analytic Hierarchy Process. After descriptive statistical analysis of the sample data [Table 4], the mean and variance of the criterion layer are shown in the table, and the mean and variance of the alternative level are shown in the tables (the data is accurate to two decimal places).

| Criteria   | Average deviation | Standard deviation |
|------------|-------------------|--------------------|
| Satisfaction | 4.42              | 0.71               |
| Easy to learn | 4.06              | 0.71               |
| Effective  | 4.15              | 0.69               |
| Error tolerant | 4.17          | 0.72               |
| Efficient  | 4.24              | 0.73               |

Table 4. Average and standard deviation data of criteria level summary table

| Criteria                        | Alternatives                                    | Average deviation | Standard deviation |
|---------------------------------|-------------------------------------------------|-------------------|--------------------|
| Satisfaction                    | Dimensions and shapes fit the human factors     | 4.51              | 0.69               |
|                                 | Good appearance                                 | 4.25              | 0.81               |
|                                 | Comfortable surface                             | 4.01              | 0.90               |
|                                 | The button needs moderate strength              | 3.97              | 0.94               |
|                                 | Key feedback sounds comfort                      | 3.94              | 0.77               |
| Error tolerant                  | Button layout conforms to usage habits           | 4.29              | 0.76               |

Table 5. Average and standard deviation data of alternatives level summary table
According to the results of the above survey data [Table 5], “The button needs moderate strength” in the satisfaction is eliminated, and the user experience evaluation system of the computer input device (keyboard and mouse) is finally determined [Table 6].

2.6 Final user experience evaluation system

| Goal | Criteria | Alternatives |
|------|----------|--------------|
| UX evaluation for computer input devices (keyboard and mouse) | Satisfaction | Dimensions and shapes fit the human factors |
| | | Good appearance |
| | | Comfortable surface |
| | | Key feedback sounds comfort |
| | Error tolerant | Button layout conforms to usage habits |
| | | Button shape and size are easy to click |
| | Easy to learn | Connect to your computer quickly and easily |
| | | Intuitive interaction |
| | | Additional functions are easy to learn |
| | Effective | Button function available |
| | | Long product life |
| | | Stable connection |
| | Efficient | Smooth use process |
| | | Efficient response |
| | | Moderate flexibility |
| | | Function buttons that simplify operation |

3. User experience evaluation model based on AHP
To calculate the weights by using AHP, giving the judgment matrix between each indicator of each level. The AHP combines qualitative analysis with quantitative analysis. The AHP is to decompose complex problems into several levels and several elements, and at the same level. Simply compare, judge and calculate, and obtain the importance of different alternatives, to provide decision-making basis for selecting the optimal solution. Constructing a judgment matrix: giving a judgment on the relative importance of each factor at each level, and using numerical values, generally using a scale of 1 to 9. [Table 7]
Table 7. UX evaluation index system weight

| Goal                        | Criteria                                      | Alternatives                                      | Single weight | Comprehensive weight |
|-----------------------------|-----------------------------------------------|--------------------------------------------------|---------------|----------------------|
| User experience evaluation index system weight for computer input devices (keyboard and mouse) | Satisfaction 0.3982                           | Dimensions and shapes fit the human factors       | 0.3407        | 0.1357               |
|                             |                                                | Good appearance                                  | 0.2865        | 0.1141               |
|                             |                                                | Comfortable surface                              | 0.2026        | 0.0807               |
|                             |                                                | Key feedback sounds comfort                      | 0.1703        | 0.0678               |
|                             | Error tolerant 0.2422                         | Button layout conforms to usage habits           | 0.6667        | 0.1615               |
|                             |                                                | Button shape and size are easy to click          | 0.3333        | 0.0807               |
|                             | Easy to learn 0.1693                          | Connect to your computer quickly and easily      | 0.4126        | 0.0699               |
|                             |                                                | Intuitive interaction                            | 0.3275        | 0.0554               |
|                             |                                                | Additional functions are easy to learn           | 0.2599        | 0.0440               |
|                             | Effective 0.1183                              | Button function available                        | 0.4434        | 0.0525               |
|                             |                                                | Long product life                                | 0.3874        | 0.0458               |
|                             |                                                | Stable connection                                | 0.1692        | 0.0200               |
|                             |                                                | Smooth use process                               | 0.3431        | 0.0247               |
|                             |                                                | Efficient response                               | 0.2426        | 0.0175               |
|                             |                                                | Moderate flexibility                             | 0.2426        | 0.0175               |
|                             | Efficient 0.0720                              | Function buttons that simplify operation         | 0.1716        | 0.0124               |

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