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# Design of Museum Science Popularization Interactive Installation Based on Embodied Cognition Theory

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## ABSTRACT

Combining embodied cognition theory and exploring innovative forms of interaction in the context of smart manufacturing, a Chinese Fan Museum science popularization interactive device was designed to provide an embodied experience. A usability evaluation model is constructed for the interactive device to evaluate the usability of the device, which will help to improve the product in the early and middle stages of its development and identify usability problems. Embodied cognition theory is applied to the interactive design of the museum science popularization information. Kansei Engineering evaluation and fuzzy analytic hierarchy process are used to evaluate and analyze the usability of the product. A usability evaluation system was constructed. The results show that the overall usability of the product is between good and excellent, and is satisfactory to users. It is feasible to explore the design of museum science popularization interaction with embodied cognition theory, and the evaluation system constructed for this product can also provide an accurate evaluation of the usability of the product and provide a reference for product upgrading and innovation.

**Keywords:** Interactive design, Museum science popularization installation, Usability evaluation, Embodied cognition

## INTRODUCTION

The China Fan Museum in Hangzhou presents the precious Chinese fan culture through historical relics and craftsmanship. With the rapid development of information and communication technology, both vertical industries and traditional fields are facing a huge technical revolution, and the traditional way of cultural exhibitions in museums is also facing an impact. Culture is a product of human society and is regarded as a spiritual activity. Therefore, combining digital technology with culture is of great importance and becoming a promising trend in recent years. This trend can be found in cultural exhibitions in museums (Tian C, Xiong W & Tong Y, 2021), where a global understanding of contemporary museum design is a synthesis that serves multiple purposes (Isikoren & Aygenc, 2018). In this era, new media such as interactive technologies are more relevant than ever to people's daily lives. New technologies are characterized by improved interactivity and presentation. Interaction design is human-centered, which can also be understood

as the design of behavior between people and everything else (Brinkerink & Drost, 2019).

Combining embodied cognition to study the application of interaction technology in museum cultural displays can create a better viewing experience for people to appreciate historical or cultural exhibitions in a more immersive and vivid way (Sooai & Purnomo, 2017). Using innovative methods to enhance subjective experiences helps us to learn and understand history and culture more easily and is more likely to make us interested in history and culture. The research design challenge for this project is to enable visitors to more authentically engage with and experience Chinese fan culture to quickly learn about it. The aim is to provide the Chinese Fan Museum with effective user insight materials, interesting forms of cultural science interaction, and to provide visitors with an embodied science interaction design that allows them to interact with the fan through gamification and further test the usability of the product (Rowe et al., 2017).

## MUSEUM SCIENCE POPULARIZATION FROM EMBODIED COGNITION

For a long time, cognition was thought to be reflection of internal brain processes, i.e., the processes by which the brain receives and organizes information (Fodor, 1975). It was not until the early 1990s that embodied cognition theory was proposed, suggesting that the sensorimotor processes of the body have an impact on cognition (Gover, 1996). Merleau-Ponty put forward the concept of "body-subject", he believed that "I" is not an abstract subject of consciousness, "I" is my "body". The body is the subject and has the ability to know and interact with the world directly. This idea rejects Descartes' mind-body dualism, in which people acquire knowledge of their external environment through bodily perception. As evidence from cognitive science continues to accumulate in support of embodied cognition theory, embodied cognition theory has developed from an early philosophical musing into a new research paradigm in cognitive psychology (Prinz, 2004), social cognition, and other fields. From a comprehensive perspective, the core ideas of embodied cognition include three components: (1) the physical structure of the body, body movement and other characteristics influence the generation and development of cognition; (2) the environment and situation in which the body is located influence the generation and development of cognition; (3) the special sensory-motor channel neural system of the brain and the body influence the generation and development of cognition.

Since the 1980s, embodied cognition has gradually shifted from metaphysical discourse to evidence-based empirical research and entered the stage of scientific verification. Numerous scholars have continued to argue for the importance of the body and its interaction with the environment for human understanding of the world. Empirical research on embodied cognition has also helped us to gain a more comprehensive understanding and appreciation of embodied cognition, applying it to different domains (McCarthy & Ciolfi, 2008).

In the field of education, scholars have developed the concept of embodied learning. Embodied cognition theory inspires the creation of contextual teaching and learning environments, and museums, as subjective learning venues, can create multisensory science knowledge and learning activities for visitors to enhance their experience. Through embodied learning, the visitor's body is mobilized to form a responsive relationship with the environment, creating an immersive learning situation. Professor Abrahamson, an internationally renowned scholar in the field of learning science, points out that embodied cognitive theory is influenced by cognitive developmental psychology and sociocultural theory, and is not only a methodology to rethink teaching and learning, but also a cognitive theory that can develop a unique learning theory. For the design of science-based interactions in museum scenarios, shaping good museum interaction scenarios includes the following experiential dimensions: relational, open, sense-making, narrative, and Spatio-temporal.

The existing researches on digital museums are mainly divided into two aspects: (1) focus on technology and interaction process (2) focus on audience-centered interactive experience. For the former one, systematic analysis and scenario application have already existed. For the latter one, existing studies analyze it from the perspective of embodied cognition by combining its theoretical framework with people's experience in the process of interaction. The existing research lack analysis combined with embodied cognition from the perspective of people themselves as well as the relationship between people's cognition, understanding, emotions and actual interactive experiences.

Combined with the embodied learning experience, a model of customer value perception is established and put into design experiments and evaluations. It can provide customer value model reference and design guidance for museum-related design evaluation and improve design quality and efficiency (Zhu, Y et al., 2021).

## QUALITATIVE RESEARCH ANALYSIS METHODS

Based on the theme of "Chinese Fan Culture", the researcher first designed an outline for the interviews, using an "hourglass structure", i.e., "peripheral questions ⟶ core questions ⟶ peripheral questions". After the preventive interview, the researcher went to the Chinese Fan Museum to conduct semi-structured interviews with 10 visitors (see Figure 1). After completing the interviews, the qualitative data obtained from the visitors were coded and analyzed using Nvivo software to classify the different visitors. By comparing the coding nodes of various types of visitors and analyzing their differences, user characteristics were extracted, and persona was depicted on this basis. Finally, the storyboard is formed: visitors enter the museum exhibit. Firstly they are watching and learning carefully, and after some time they will communicate and share with their friends by shooting videos, excitedly trying to interact with the exhibits, but they find that the interactive forms are less available and not attractive enough. At the same time, exhibits are usually

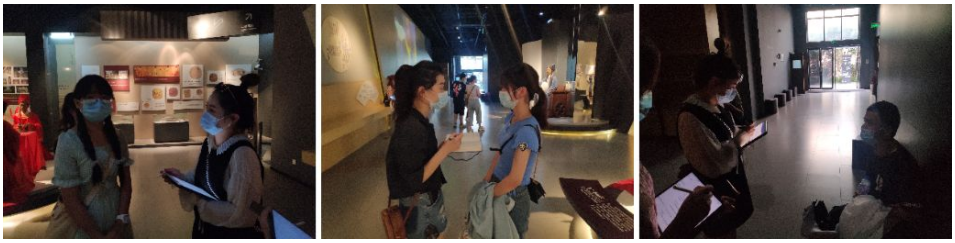

**Figure 1:** Interviews with museum visitors. (Photo by author).

displayed with very small text information boards and huge screens, lacking articulation.

## DESIGN STRATEGY

The design takes the classical Chinese folk love story "Liang Zhu" as the theme, and in the drama "Liang Zhu", a folding fan is used as a prop, and the fan sometimes turns into a butterfly and dances, sometimes acts as a book to create a lively learning scene, which is very interesting. The central visual scene of this interactive science design is the scene in "Meeting on the Terrace": two visitors arrive at the booth, and the text "Please follow the instruction and wave the fan" is displayed on the left side of the screen with an illustration. On the right side, a butterfly flutters with the text "Please wave the fan at the same frequency". When the visitors wave the fan, they control the left and right wings of the butterfly respectively, and when the frequency reaches within the tolerance of the set similar frequency, the content of the screen changes to an animation of a butterfly fluttering from the mountains, and continue to play the clip of the drama "Liang Zhu" (see Figure 2).

The design uses Processing and Arduino for interactive design, attracts visitors' attention through an interactive game, gives them interesting feedback after they complete the set actions, and then popularizes fan culture with the help of the drama "Liang Zhu" after they focus on it.

## USABILITY EVALUATION

The perceptual vocabulary represents the consumer's subjective impressions of the product and reflects the psychological impact of product usability on the user. The user's use of this museum science popularization interactive installation involves the user's instinctive layer, behavioral layer, reflective layer and ergonomics. An initial vocabulary of 80 perceptual terms was summarized based on these aspects. In this paper, using the Delphi method, 10 experts were invited to judge these 80 perceptual words. Finally, 15 perceptual words that best represent users' impressions of usability were selected as evaluation indexes.

The multi-level index model of the museum science popularization interactive installation was divided into three levels using hierarchical analysis: target level A, criterion level B and index level C. The target level is the overall usability of the museum science popularization interactive installation;

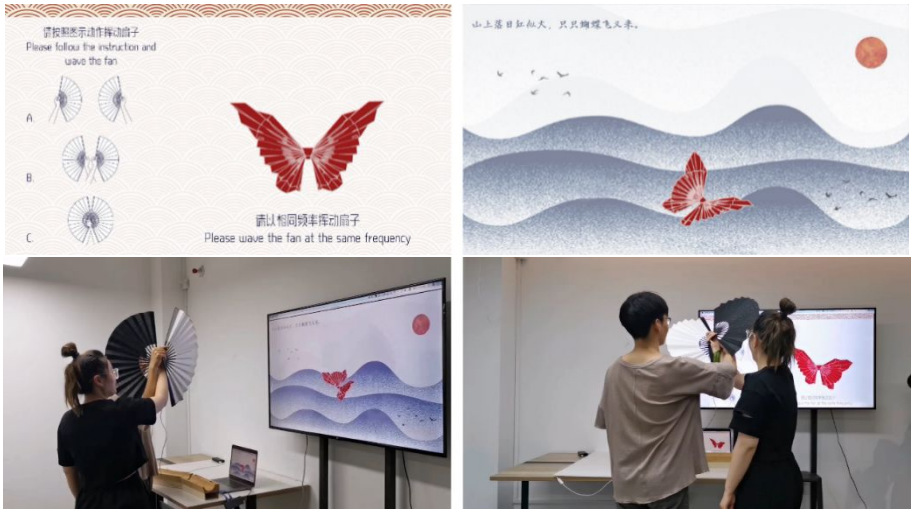


**Figure 2:** Design images and interactive prototypes. (Photo by author).

the criterion level is the appearance usability, operation usability and perceived usability; and the index level is the specific index factors for evaluating each usability, which constitute the basic 3 levels of usability indexes of the product.

The five-level scale method was used to compare the target and criterion levels and construct a judgment matrix. Designers and expert users were invited to form a panel of experts to conduct a comparative analysis and collect their questionnaires, and the Delphi method was used to focus the opinions of the panel until the final results were consistent. Finally, the judgment matrix is tested for consistency, and the consistency ratio formula is calculated as follows(In the equation: $\lambda$max - maximum eigenvalue; n - matrix order. RI - average random consistency index. CI - consistency index. when CR < 0.1, the consistency test is passed, otherwise the judgment matrix will be re-corrected until it is passed.):

$$C_I = (\lambda max - n)/(n-1) \quad (1)$$

$$C_R = C_I/R_I \quad (2)$$

According to the fuzzy values in the judgment matrix, the weight values of each layer of indicators are solved with the help of the hierarchical analysis software Yaahp. The weight values reflect the degree of influence and importance of each perceptual evaluation index on the overall usability of this museum science popularization interactive installation. The results show that users attach the most important to the perceived usability of this design, followed by the operational usability (see Table 1).

The product was evaluated by 30 users who were selected to test the product. The users were introduced to the product through the product demonstration video and experienced the product operation interaction process, and then rated the product based on 15 typical terms of the 3-level index.

**Table 1.** Multi-level index model of product availability and data of weight distribution (Data from Yaahp).

| Overall goal | Level 1 Indicators | Weight value | Level 2 Indicators | Weight value |
|---|---|---|---|---|
| Overall availability A | Appearance availability $B_1$ | 0.1428 | Close | 0.1540 |
| | | | Nice-looking | 0.0799 |
| | | | Intuitive | 0.4233 |
| | | | Attractive | 0.2268 |
| | | | Textured | 0.1159 |
| | Operation availability $B_2$ | 0.2857 | Controllable | 0.1605 |
| | | | Visible | 0.2781 |
| | | | Learnable | 0.4002 |
| | | | Responsive | 0.0667 |
| | | | Simple | 0.0945 |
| | Perceived availability $B_3$ | 0.5715 | Harmonious | 0.0647 |
| | | | satisfied | 0.1882 |
| | | | Reliable | 0.2593 |
| | | | Pleasant | 0.1310 |
| | | | Interesting | 0.3568 |

The users were selected by Likert scale of excellent, good, moderate, qualified and poor to evaluate the level. The rating levels correspond to a score of 5-1. By calculation, the final total score of all users, which is the rating of the overall usability of the product was obtained. The average of the overall usability comprehensive evaluation score of 30 users: $A = 4.6461$, according to the correspondence between the fuzzy evaluation grades and scores, it can be seen that the overall usability of this museum science interactive device is between good and excellent. It is closer to excellent (5.00 points), indicating that users are basically satisfied with the usability of the design. From the statistics of users' ratings of typical perceptual terms, there is still a need to improve and refine the reliability and response sensitivity of the product.

## CONCLUSION

The design of the Chinese Fan Museum science popularization interactive installation broadens the way of museum science knowledge. Two visitors interact with the fan and watch the butterfly animation on the display, using interesting human-computer interaction to help visitors get a personal learning experience. They can understand the "Liang Zhu transformed into a butterfly", an ancient Chinese folk story related to the fan. So that the Chinese traditional culture is well inherited. This study uses hierarchical analysis to effectively test the usability of the product and provide directions for product design iterations.

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