從使用性工程探討生手與專家使用者操作投影機之研究

A Usability Engineering Study on the Operation of Overhead Projector by Novice and Expert Users

陳昱丞
Yu-Cheng Chen

環球技術學院商品設計系

摘 要

在強調使用者親和性的現代設計趨勢中，仍然充斥著相當多不合理的設計，除了會造成使用者的操作不便外，更嚴重者甚至可能造成人身的傷害，因此近來相關領域的專家學者提出了使用性工程的觀點，希望透過客觀的測試與研究，探討使用者於操作過程中有關學習性、效益性、記憶性、錯誤率與滿意度等使用上的特性。

本研究所選定的主題爲投影片所使用的 OHP 投影機，因其介面設計有若干值得深入探討與改進，因此計畫以使用性工程中的「簡化邊說邊做法」及「影音回溯法」爲實驗的主軸，透過生手與專家使用者的實地進行投影機操作的邊說邊做，利用攝影機加以攝影記錄後針對影片內容進行影音回溯分析，藉以瞭解專家與生手使用者的心智模式之差異，並分析其完成各階段動作所需之時間。

研究發現本次所探討的投影機對於生手來說其操作性並不理想，相關的結論將可供設計師於進行投影機介面設計時之參考依據，以期改善目前現有投影機介面設計不良的部分，除可提高產品使用效率外，並可避免因操作不當所可能產生的重大危險。

關鍵詞：心智模式、簡化邊說邊做法、影音回溯法

Abstract

In spite that the trend towards more user friendly interface in contemporary design is growing, considerable improper designs nowadays can still be easily found out from many systems or products. Such improper system or product designs may result in inconvenient operations for users, and what is more, cause serious harm to the physical health. Therefore, specialists and scholars in the relevant field recently proposed the viewpoint of usability engineering by dint of impartial testing and researches on the characteristics of learnability, efficiency of use, memorability, frequency and severity of errors and subjective satisfaction while a user is operating a product or a system.

The study employed an overhead projector (OHP), which has several interface designs need to be improved, to be operated by both inexperienced and skilled users through the experiments with “Simplified thinking aloud” and “video/audio protocols” of the usability engineering. We also utilized a video camera for filming the OHP operations by both inexperienced and skilled users by the thinking aloud method and then carried out the film analyses by video/audio protocols. Consequently, the mental model differences between both inexperienced and skilled users and required operating times in various phases are well analyzed.

It is found from the study results that inexperienced users do not operate OHP well. Relevant conclusions can be provided for OHP designers as the interface design reference for making the functionality of an OHP more suitable for user needs, moreover, enabling existing poor OHP interface designs to be improved. Consequently, a better OHP interface design is able to heighten usability of the product, in addition, prevent possible serious hazards from improper OHP operations.

Keywords: Mental Model、Simplified Thinking Aloud、Video / Audio Protocols

1.Introduction

The issue of use inconvenience was first noticed in the development of graphic user interface by software programmers, who generally attributed it to deficiencies of "user-friendliness." However, Nielsen argued that users do not require friendliness by machines but smoothness in daily operation. Besides, the phrase "user-friendliness" carries the implication that human-machine relationship is unilateral, which in fact varies with dispositions of individual users. Nielsen therefore suggested that it would be more appropriate to define such issues with usability engineering. Any aspect associated with usability, or how well a user can exploit the functionalities provided in a system or product, can be examined from the view of usability engineering.

Usability engineering should not be considered as unilateral in user interface but incorporating differences among operators. The following five characteristics should be taken into account:

(1) Learnability: The system should be easy to pick up so that the user can quickly perform the correct operation.

(2) Efficiency of use: High quality performance and production can be anticipated once the user has acquired the knowledge about operation.

(3) Memorability: System operations should be easy to remember. Even intermittent users do not need to learn from the basic after a long period of time without operation.

(4) Error rate: Error rate should be reduced as much as possible to avoid any fatal mistake.

(5) Subjective satisfaction: Operation should be satisfactory enough for users to generate fondness of the system.

It was discovered that the insistence on optimization of everything would more than often result in the shortage of feasible measures. Hence, some experts have proposed the idea of "Discount Usability Engineering", which aims to adopt concise yet essential technologies in the search of "good" solutions. This concept is based on four aspects: user and task observation, scenarios, simplified thinking aloud, and heuristic evaluation.

When studying an unknown research subject, researchers usually employ a hypothesized model, or the commonly called "working model". In face of unfamiliar objects, people generally would construct an assumptive working model and validate the model through trial and error. The working model is referred to as "the mental model". With regard to the versatile and multifunctional presentation of digital media as human-machine interface, user's conceptions about how a digital system should be presented and operated can also be viewed as a mental model.

Three approaches can be observed in the process of user-centered design: approximate user's mental model to that of designer, adjust designer's mental model to be that of users, and moderate designer's mental model to be similar to that of users. The last method is more compliant with the spirit of user-centered design. A good usability design requires that the designer pre-simulates target user's mental model and operational inclination, so as to develop a comprehensible and easy-to-use user interface accordingly.

Gentner & Stevens (1983) defined the mental model as follows: 1. A mental model is a model that naturally evolves in the mind of a user; 2. A mental model is not integral, so it is being constructed at all times; 3. Human's ability to control the model is very limited; 4. A metal model is so unstable that people cannot retrieve detailed information after a long period of time; 5. A mental model does not have any specific boundary, so similar instruments and operations can easily cause confusion.

2. Research Methods and Procedures

This study was performed through the two approaches of simplified thinking aloud and video/ audio protocols. Both novice and expert users were invited to operate an overhead projector (OHP). A camera was employed to film the procedure and record their voice. Through the simplified thinking aloud method, mental models and problem-solving procedures by both expert and novice users as they explored through the operation of the said OHP were recorded. Finally, video/ audio protocols were applied to time, code, and analyze the recorded data. The research procedure is illustrated in Figure 1.

(1) Pilot test

In order to prevent failure from unexpected errors, a pilot test was performed. Prior to the formal experiment, necessary modification of the experiment method was made in accordance with the results of the pilot test.

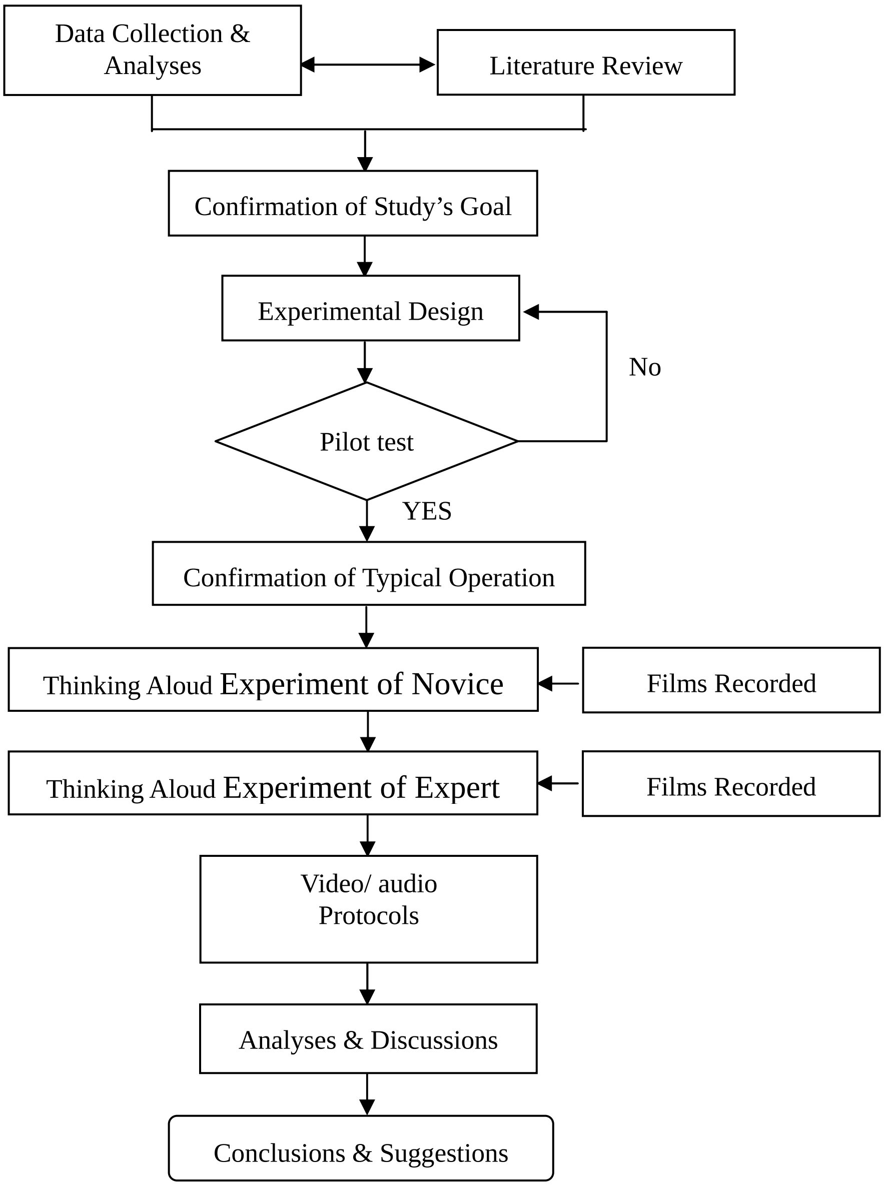

Figure 1. Research procedure

(2) Confirmation of typical operation procedures

Typical operation procedures, or standard operation procedures, should be determined to facilitate analysis and comparison between operational inclinations by novice and expert users. Further, the task sequences were simplified to several key stages, and the assigned tasks of the experiment were categorized into typical operation procedures for commencement (step 1.x) and typical operation procedures for stowing (step 2.x).

Typical operation procedures for commencement:

step 1.1 Open the upper lid step 1.2 Position the projector arm step 1.3 Position the mirror assembly

step 1.4 Close the upper lid step 1.5 Plug in the power cord step 1.6 Power on

Typical operation procedures for stowing:

step 2.1 Power off step 2.2 Store the power cord step 2.3 Open the upper lid
step 2.4 Stow the mirror assembly step 2.5 Stow the projector arm step 2.6 Close the upper lid

(3) Simplified thinking aloud experiment

In this stage, we kept track of novice and expert users' mental models and behavioral characteristics as they explored the operation of assigned projector for the first time. The purpose was to present user's implicit mental model via the approach of simplified thinking aloud. Further, action analysis was conducted to figure out individual behavioral dispositions and causes of difficulty in operation. The experimental subjects in this study were defined as follows. The novices were general users who have never operated any projector before; expert users refer to professionals who have experienced design practices and operated projectors other than the model used in this study.

The thinking aloud method on the other hand has long been used in psychological studies, and has been gradually applied to man-machine interface evaluation. The major downside of this method is that it does not offer enough information for quantitative measurement. However, it allows the researcher to obtain very detailed small data about the user, which can be based upon for qualitative analysis.(Jakob Nielsen, 1993)

Berry and Broadbent applied a write-down method for users to jot down how they face and carry out a specific task in their study and found that the thinking aloud method is 9% faster than the write-down method in terms of the time required for experimentation.(Berry & Broadbent, 1990) They held the view that language expression not only reinforces the concept about task demands among the users, but also helps them work more efficiently. In another research study, it is found that between the two groups of users operating different file systems, the error rate of think-aloud users is only 20% of that of quiet users. In addition, the think-aloud users work twice as fast as the quiet users. (Wright & Converse, 1992)

Simplified thinking aloud experiment required the subjects to speak out reasons and assumptions for their actions as they operate the projector. Meanwhile, the experimenter recorded the whole process with camera, so as to analyze user's mind by what was filmed. This allows the researcher to recognize the interaction between the user and the interface, as well as the motivation behind each action. Such observation is contributive to precise identification of factors that cause user's mal-operation.

This experiment was performed in an enclosed space without external disturbance. First, the experimenter gave the subject a brief introduction of the experiment. Two tasks were assigned to the subject: installation and stowing of the projector. A camera was used to keep video and audio records during the operation.

(4) Video/ audio protocols

Films recorded during the above-mentioned experiment were closely examined to record subject's verbal and physical reactions. Findings were summarized in the two columns of "verbal records" and "user's response" in Tables 1 and 2. For the recognition of defects in the user interface, both subjects were timed to figure out the duration for the completion of each stage in the two tasks. The detailed results are provided in Tables 1 and 2.

(5) Coding

Before analyzing the verbal records obtained in the experiment, it is necessary to construct a coding system covering the four essential aspects of raw material; namely, C.O.P.E, the conceptual, operational, perceptual, and evaluation aspects. As this study aimed to investigate characteristics in user interface of projector, a coding system of D.M.O.T was established for verbal analysis via literature review, describing the four facets, namely doubt, movement, observation, and try. It was expected that codification of verbal records could facilitate quantitative analysis on qualitative data, as well as comparison between mental models of novice and expert users when they were confronted with issues associated with operation interface.

Table 1. Operation by the novice user

	Verbal records	User's response	Operation time
Step 1.1	Open the lid.		5sec
Step 1.2	How should I handle it? Is there any manual? I don't get it! I hope this is right.	Groping around Fumbling with the projector	51 sec
Step 1.3	Press it down, lift it up.	Examining the structure of the mirror assembly.	15 sec
Step 1.4	Close the lid.		5 sec
Step 1.5	Where is the power cord? Oh, there it is. Let me plug it on.	Looking around	15 sec
Step 1.6	Turn on the power. Done.		4 sec
Step 2.1	Power off.		3 sec
Step 2.2	Unplug and stow the power cord.		13 sec
Step 2.3	Open the lid.		6 sec
Step 2.4	Press it down. Ok.		5 sec
Step 2.5	How do I stow the arm? I don't understand the manual. Here is a sheet iron. Let me try. Ok, that's it. Lower it down.	Looking around	37 sec
Step 2.6	Close the lid.		5 sec

Table 2-1 Operation by the expert user

	Verbal records	User's response	Operation time
Step 1.1	Release the metal buckle and open the upper lid.		5sec
Step 1.2	Then stand the arm, right? Okay, that's it.	Thinking briefly.	16 sec
Step 1.3	Press it down. Rotate to move it up.		8 sec
Step 1.4	Close the lid.		4 sec

Table 2-2 Operation by the expert user

	Verbal records	User's response	Operation time
Step 1.5	Where is the power cord? Here it is. Plug it.	Bending over to check it out.	11 sec
Step 1.6	Power on.		5 sec
Step 2.1	Power off.		2 sec
Step 2.2	Unplug and then stow the power cord beneath the projector.		12 sec
Step 2.3	Open the lid.		5 sec
Step 2.4	Press it down and rotate.		6 sec
Step 2.5	I can't press it down. There should be a switch for it. It should be this iron sheet. Ok, it works. Restore it.	Bending over to check it out.	25 sec
Step 2.6	Close the lid.		4 sec

3. Analyses and Discussions

The coding system proposed in this study was employed to codify the examinees' verbal and behavioral records. Results of verbal analysis are shown in Table 3, it's organized and provided from Tables 1 and 2; the parenthesized digits stand for frequency of the code. It can be found from the preliminary analysis on the records that both novice and expert users encountered difficulties of various degrees in steps 1.2, 1.5, and 2.5.

Table 3. Results of protocol analysis

	Protocol analysis on the novice	Protocol analysis on the expert	Note
Step 1.1	M(1)	M(2)	
Step 1.2	D(3) O(1) T(1)	D(1) M(1) O(1)	
Step 1.3	M(2) O(1)	M(2)	
Step 1.4	M(1)	M(1)	
Step 1.5	D(1) M(1) O(1)	D(1) M(1) O(1)	
Step 1.6	M(1)	M(1)	
Step 2.1	M(1)	M(1)	
Step 2.2	M(2)	M(2)	
Step 2.3	M(1)	M(1)	
Step 2.4	M(1)	M(2)	
Step 2.5	D(2) M(1) O(1)	D(1) M(1) O(1)	
Step 2.6	M(1)	M(1)	

Further, data related to operation time by the subjects were analyzed and diagrammatized as in Figures 2 and 3. Significant difference in time interval between novice and expert users was found in steps 1.2, 1.3, and 2.5.

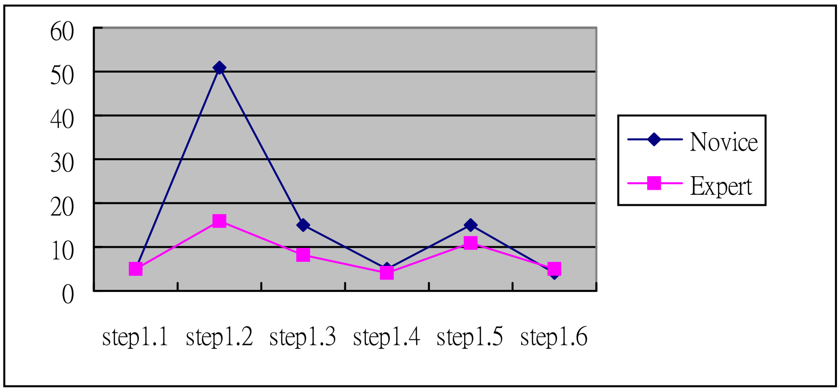

Figure 2. Comparison between time spent for projector commencement by novice and expert (Unit: second)

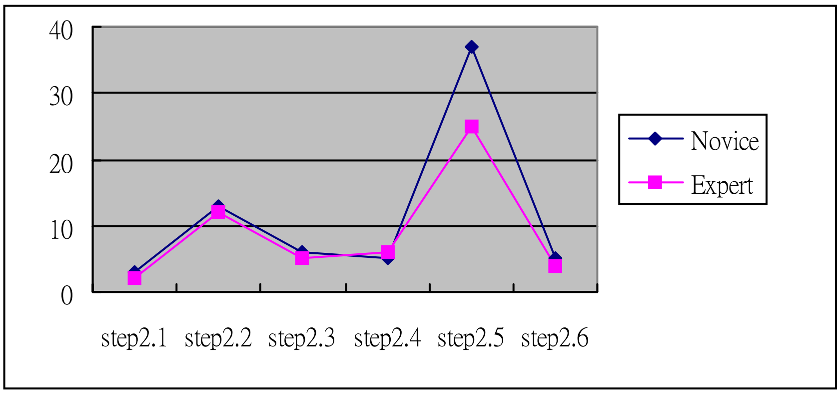

Figure 3. Comparison between time spent for projector stowing by novice and expert (Unit: second)）

4.Conclusions and Suggestions

Findings of this study revealed that neither novice nor expert users could immediately figure out the correct operation method in steps 1.2 (position the projector arm), 1.5 (plug on the power cord), and 2.5 (restore the projector arm). They all needed to undergo observation as well as trial and error. In particular, the operation of projector arm took most time; for example, the novice user spent 51 seconds on step 1.2 of commencement task and 37 seconds on step 2.5 of stowing. Therefore, it can be inferred that there is still room for improvement in the operation interface design of the projector arm.

Only a difference of 56 seconds was observed between the durations of operation by novice and expert users; the novice user spent 160 seconds to accomplish the assigned task while the expert user spent only 104 seconds. It was obvious that experience in the operation of similar equipment has considerable influence on the initial operation of the projector assigned.

It can be observed from results of the verbal analysis that both novice and expert users held a similar mental model when confronted with difficulties during their initial operation of the projector used in the experiment of this study, only that they differed in duration required to accomplish all the tasks. Thus, the interface design of the projector was not ideal, because even a professionally trained expert user was hindered from full comprehension of the designer’s mental model. In other words, the designer’s mental model did not approximate to that of end-users, causing misunderstanding of the interface, inconvenience, and occurrence of mistake.

It can be inferred from the results of this study that usability design of the selected projector was not satisfactory. The efficiency was not fulfilled at all, especially for a novice user who had no experience about the operation of any type of projector. Therefore, further studies can be focused on learnability and memorability of the interface, so as to determine if such product is created for professional use and more detailed and comprehensible operation directions should be provided for first-time users.

References

1. Berry, D. C., and Broadbent, D. E., 1990, “The Role of Instruction and Verbalization in Improving Performance on Complex Search Tasks”. Behaviour & Information Technology 9,3
2. Gentner, D., & Stevens, A. L. (Eds.).,1983, *Mental models. Hillsdale*, NJ: Lawrence Erlbaum Associates MA.
3. Jakob Nielsen,1993, *Usability Engineering, AP Professional*.
4. Wright, R. B. & Converse, S. A. ,1992, “Method bias and concurrent verbal protocol in software usability testing”. Proceedings of the Human Factors Society 34th Annual Meeting, 1285-1289. Santa Monica.