

USER CENTERED DESIGN AND TESTING METHODS FOR THE DEVELOPMENT OF THE MENU SYSTEM FOR MOBILE PHONES

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User centered design and usability evaluation of mobile devices are becoming important activities in the development process of mobile products. This paper presents a case study and introduces different techniques to support the process of designing a menu system embedded into a mobile phone. These techniques facilitated a systematic user needs analysis in the early stages of the development life-cycle, to formulate a navigational structure for designing prototypes, to identify usability problems for iterative prototype design, and to develop design guidelines. The introduced techniques involve laddered grid methods to elicit users' mental models, focus groups, usability testing, and expert reviews. The advantages and disadvantages of each method used during the design project were summarized, and usability practitioners in the real environment of the mobile devices industry are advised to be selective the combination of items they incorporate to suit their purposes.

INTRODUCTION

Mobile products can be developed and sold successfully without special emphasis on interaction or interface design considering usability or human factors problems (Ketola, 2002). However, the usability of mobile phones has become an issue for mobile phone manufacturers and users due to the complexity of the functions embedded into the phones, such as the Short Messaging System (SMS) and Voice Activated Dialing (VAD). Due to increasing competition in incorporating newer technologies and more functions, manufacturers need to apply user-centered design and testing activities in the development life-cycle. However, applying user-centered design methods in real development environments has been difficult, because of the distance between the users and the developers, confidentiality regarding innovative products, and the short time-to-market characteristics of the development process (Kadyte & Tetard, 2004; Sawyer, 2001).

This paper is based on a research project sponsored by a mobile phone manufacturer; it introduces user-centered design and usability testing methods, and examines how these methods facilitate the design of the menu navigation system and the interface of a mobile phone.

METHOD

The overall study employed an interactive design with both qualitative and quantitative methods, as shown in Figure

1. The figure also illustrates the methods, sub-techniques, and the outputs used in a sequential manner.

Method	Sub-technique	Output
Laddered grid method	One-to-one interview Think aloud Expert review	Navigation flow diagrams
▼	▼	▼
Focus group	Consensus Usability heuristics	Selection and modification of navigation flow diagrams Final design mock-up Mid-to-high fidelity Flash prototype
▼	▼	▼
Usability testing	Performance testing Retrospective think aloud (RTA) Questionnaire	Navigation diagram Critical incidents Usability problem list High fidelity Flash prototype
▼	▼	▼
Expert review	Heuristic analysis Usability walkthrough Questionnaire	Usability problem list Design recommendations Final Flash prototype

Figure 1. The sequential procedure of the mixed-methods approach using the usability engineering techniques.

Laddered grid Method

The laddered grid method (Cordingley, 1989) elicited users' mental models of cell phone navigation with regard to designated cell phone functions. This method, administered using paper and pencil, provided users with a simple method

to express their mental models of navigation. Twelve US citizens (Mean age = 22.92, SD = 3.15), six male and six female, all novice or intermediate users, participated. Navigation flow diagrams were elicited for three phone functions: Phone Book (PB), Short-messaging service (SMS), and Voice-Activated Dialing (VAD). Two tasks within each function were selected. Participants were given a practice task then asked to produce mental models using the laddered grid symbols including boxes, ovals, lines, and arrows (Figure 2). In addition, participants were asked to think aloud while illustrating their mental models. A post-task interview was conducted after each task. Common navigation flow diagrams were derived using expert review, coding of several attributes or markers by the research team, and analysis of patterns from the think aloud data and post-task interview responses.

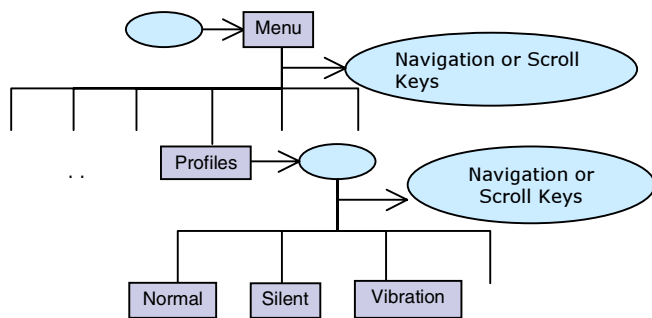


Figure 2. A sample laddered grid describing ringer change task

Focus Group

Focus group sessions were performed to verify the navigation flow diagrams derived from the laddered grid method. Two separate focus groups, consisting of five intermediate users (mean age = 23.4, SD = 3.78) and four novices (mean age = 23.9, SD = 2.89) were conducted respectively.

Participants were given several minutes to evaluate the intuitiveness and ease-of-use of the current design. Participants were allowed to redesign the flow diagram to increase its ease-of-use if necessary. Following the work session, participants were asked to rate the final team design on several usability attributes. Time to reach agreement was also recorded. The results of both focus group sessions were compared. When results conflicted, the final navigation flow diagram was designed in favor of the novice group, assuming that this would achieve a design with broad intuitiveness. Usability heuristics were also applied to produce the final design mock-up, which was then used to develop the working prototype.

Usability Testing with Prototype

Usability testing with the prototype derived from novice and intermediate users' navigation flow diagram was performed. The prototype was developed using Macromedia Flash MX™. The prototype supported the interactions necessary to complete the tasks being tested. Twenty-eight participants were selected for the usability test: sixteen from the US and twelve from West Africa, South America, and

Eastern Europe. Participants completed several tasks, generated retrospective think-aloud data, and responded to a post-task questionnaire and interview. More details of this method were described in Lee, Ryu, Smith-Jackson, Shin, Nussbaum, and Lee (2005).

Expert Review

Three expert reviewers verified the usability of the final prototype and its potential as a design tool. They conducted a heuristic analysis using guidelines derived from the previous studies and general usability guidelines for interface design. They also conducted a usability walkthrough of tasks and provided a usability problem list and recommendations. A final questionnaire collected their opinions of the usefulness of the prototype as a design tool and their recommendations.

RESULTS

Laddered grid

Several common patterns, some of which differed between novices and intermediates, were identified. The common patterns consisted of the initial starting point, top-level menu complexity, movement pattern, scroll pattern, use of exit/escape or back/cancel keys, labels, and key locations. Navigation flow diagrams were developed based on these patterns and confirmed by the focus groups later.

Focus Group

Analyses of the focus group data consisted of mapping the final menu and navigation structures based upon the common design flow diagrams developed by each group. All post-task responses related to common assumptions and logic from the video-taped records and observation notes made during the focus group sessions were content-analyzed. Furthermore, the electronic navigation flow diagrams with iterations of the menu and navigation structures were provided using PowerPoint.

Individual questionnaires asked after each task were analyzed to judge the quality of the final menu structure in terms of ease of completing the task, the degree to which the task matched the participants' expectations, the meaningfulness of the labels, the degree of guidance afforded by the selected design, and overall satisfaction using 6-point Likert-type scale.

User requirements and design specifications are being developed based upon the common mental models derived from the focus groups. Finally, qualitative analyses of the within-group deviations were provided to make further recommendations regarding customization or universal design. The convergence ratings were developed by using a combination of the mean "overall satisfaction" rating from the individual questionnaires and the time taken to reach agreement. According to the convergence ratings, SMS sending task was rated by novice users as the most challenging task, while VAD registering task was deemed most challenging by intermediate users.

Usability Testing with Prototype

Quantitative data from the usability performance testing and the ratings of usability were provided. For example, task completion times were compared among the tasks and between the groups of participants. Subjective ratings of the usability of the interface and navigation designs revealed which task was rated as significantly more usable compared to all others.

Navigation diagrams were developed based upon an analysis of the video recordings made during each usability session. Finally, usability problem and critical incident lists were generated from observations made during the usability sessions. The prototype was redesigned and presented to three external reviewers.

Qualitative data were also gathered from retrospective verbal protocols and from the post-task interviews. Comparisons were made between cultures (US vs. International). In general, users agreed on the degree of supportiveness of the interface, however, several US participants remarked on the lack of supportiveness of the icons for each task. International participants placed more emphasis on the appearance of the interface over the function, while US participants placed more emphasis on function. Overall, participants did not think that cultural customization was necessary beyond ensuring that languages relevant to the user cultures were programmed into the phone.

Expert Review

Experts identified several navigation problems requiring additional changes to enhance usability. Among several important problems, forward navigation was considered to be intuitive, but backward navigation was difficult. Icons were difficult to discern; however, some of this difficulty was due to the software used in the prototype. The search function was considered important, but was found to be difficult to locate.

Several modifications were made to the prototype on the basis of expert reviews. Experts also reported that the prototype could potentially become a usable design tool, but would need to be easily customizable by the end designers. Thus, documentation coding should be provided to ensure that designers can test new ideas using the prototype. In addition, reviewers reported that the tool would be more helpful during early formative evaluation rather than in later testing during the design cycle.

DISCUSSION

Laddered grid

The laddered grid method is an effective tool to derive users' mental models, which represent navigational flow diagrams in this study. This method was particularly effective in circumventing the influence of existing designs, since the participants drew on blank papers without any visual aid or framework. Intermediate users may remember designs from their experience, although it could be still challenging. The designs of novice users were very unconventional since they had less experience with a cell phone. They also tended to

draw illogical maps beyond the capability of current technology. However, it showed the possibility of obtaining creative ideas. In general, this method supported eliciting users' mental models, though the data was difficult to analyze. A systematic analysis methodology should be developed.

Focus Group

One of the important lessons of the focus group sessions was the challenge in using focus groups as a verification and selection process of design alternatives. During these sessions, each participant could express individual opinions freely, and they rarely reached agreement among the alternatives. Nevertheless, it was useful in selecting nomenclature for menu and buttons labels.

Usability Testing with Prototype

The valuable output of this method is the critical incidents and possible navigational flows that the designers did not expect or consider from the previous methods. Also, this session could provide relative levels of difficulty among the sets of task set up for the testing. There are many tasks for phone usage, such as phonebook management, sending or deleting text messages, and voice activated dialing. Once these tasks are tested using prototypes, the results could provide quantitative data regarding completion time, number of errors, and unexpected navigational flows for each. Thus, designers would have information to guide attempts at greater improvements among the task sets.

Expert Review

The procedures and outputs of the expert review session were very similar to usability testing, except that the evaluators were usability experts. Thus, this session provided additional information regarding the usability problem list and design recommendations, which were input to finalize the prototype. The expert reviews required much less time and cost than the usability testing to produce design information. Therefore, this method is recommended for various usability projects. However, this method may not play a main role in user-centered design projects because the expert analysis cannot yield non-expert usage patterns.

CONCLUSION

Based on the design project results, the advantages and disadvantages of each method used were summarized in Table 1. Each method could complement the others, although there are some areas of redundancy.

As indicated in the introduction, several constraints prevent designers and developers from using all methods available. Thus, usability practitioners in the real environment of the mobile devices industry should identify the advantages and disadvantages of the methods, then selectively employ an effective combination of those within their limitations.

Table 1. Comparison of the methods used in this study

Method	Advantage	Disadvantage
Laddered grid	Hard to be influenced by current designs Good to get ideas from novice users Good to get creative ideas	Time and cost
Focus group	Good to determine nomenclature and design of icons	Hard to use as a confirmation tool
Usability testing	Good to identify critical incidents and unexpected navigational flows Good to determine relative level of difficulties among task sets	Time and cost Impossible to test every task
Expert review	Easy and cost effective	Lack of user's point of view
Flash prototyping	Good for early formative evaluation Relatively easy to develop high-fidelity prototype	limited for handheld devices

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