

# Development of Usability Questionnaire Items for Mobile Products and Content Validity

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## Abstract

Electronic mobile products have become a major indicator of consumers' life styles and primary tools for everyday life. Based on the popularity of electronic mobile products and the need of a usability questionnaire tailored to them, questionnaire sets for mobile phones and PDA/handheld PCs were developed. The definition of usability in ISO 9241-11 was used to conceptualize the target construct, and the initial questionnaire items pool was comprised of various existing questionnaires, comprehensive usability studies, and other sources related to mobile devices. Through redundancy and relevancy analyses completed by representative mobile user groups, a total of 124 items (119 for mobile phones and 115 for PDA/Handheld PCs) were retained from the 512 items of the initial pool. The resulting questionnaire sets will be helpful for usability practitioners in the comparison of competing electronic mobile products in the end-user market, evolving versions of the same product during an iterative design process, and selecting alternatives of prototypes during the development process. However, to increase reliability and validity of the questionnaires, follow-up studies employing psychometric theory and scaling procedures are in progress and will provide a refinement of the items.

## 1 Introduction

There have been many efforts to develop usability questionnaires for software product evaluation. However, there have been indications that existing questionnaires and scales such as SUMI, QUIS, and PSSUQ are too generic (Keinonen, 1998; Konradt, Wandke, Balazs, & Christophersen, 2003). The developers of those questionnaires indicated that deficiencies in their questionnaires can be taken care of by the establishment of a context of use, characterization of end user population, and understanding of tasks for the system to be evaluated (van Veenendaal, 1998). To integrate those considerations into the usability questionnaire, the need for more specific questionnaires tailored to particular groups of software products has increased. In response to the need, questionnaires tailored to particular groups of software have been developed, such as Website Analysis and Measurement Inventory (WAMI) (Kirakowski & Cierlik, 1998) for website usability, Measuring Usability of Multi-Media Systems (MUMMS) for the evaluation of multimedia products, and the Usability Questionnaire for Online Shops (UFOS) (Konradt et al., 2003) for measuring usability in online merchandisers. However, since the existing questionnaires focus on software products, they may not be applicable to electronic consumer products because, in addition to the software (e.g., menus, icons, web browsers, games, calendars, and organizers), the hardware (e.g., built-in displays, keypads, cameras, and aesthetics) is a major component.

In the meantime, definitions and concepts of usability have evolved along with the increased interest in the usability of consumer products. The definition of usability for electronic consumer products should be expanded to include the image, impression, or aesthetic appeal of the products in addition to their performance (Dunne, 1999; Kwahk, 1999). Also, new emotional dimensions, such as pleasure to use, for usability measurement have been introduced for consumer products (Jordan, 2000; Logan, 1994). Thus, the need for new usability questionnaires for consumer products is inevitable, not only in terms of the new domain of target products but also in terms of evolving definitions and concepts of usability. However, the development of a questionnaire for general consumer products would carry an inherent deficiency similar to those of existing questionnaires for software products, as indicated in the previous paragraph, because there are numerous types of consumer products in the market, such as audio-video

product (e.g., TV and VCR), healthcare products (e.g., glucose monitor and heart rate monitor), and mobile products. Thus, a questionnaire tailored to a specific product group would be more meaningful for that group.

As a relatively new group of consumer products, mobile products have become one of the most popular products in consumers' life styles because they are suffused with personal meanings and individual experiences, are carried from home to work and to leisure places, and not only provide communication whenever needed but also become a primary tool for life management (Ketola, 2002; Sacher & Loudon, 2002; Vninen-Vainio-Mattila & Ruuska, 2000). Also they have been recognized as an important indicator of consumers' tastes for buying other groups of products (PrintOnDemand, 2003). At the same time, mobile products clearly consist of two components (e.g., hardware and software), and aesthetic appeal and image may play an important aspect in their usability evaluation. Thus, mobile products are selected as worthwhile target products for the development of a new usability questionnaire.

The goals of this study are to clarify the construct definition and content domain in order to develop a questionnaire for the evaluation of electronic mobile products and generate measurement items for a usability questionnaire. The first study conducted an extensive survey of usability literature to collect usability dimensions and potential items for electronic mobile products. According to Clark and Watson (1995) and Loevinger (1957), the initial pool considered in developing a questionnaire should be broad and comprehensive and include even items unrelated to the target construct. Thus, although the target products (electronic mobile products) of this research are relatively specific, usability dimensions and criteria from various literature were examined regardless of the target product. Before conducting the extensive survey of literature, the conceptualization (i.e., specification) of the target construct and content domain was clarified. The second study involved a couple of experts knowledgeable in the content area and representatives of various user groups to review and judge the collected items pool from Study 1.

## 2 Study 1: Conceptualization and Development of Initial Items Pool

### 2.1 Conceptualization

According to various guidelines for the development of questionnaires (Clark & Watson, 1995; DeVillis, 1991; Netemeyer, Bearden, & Sharma, 2003), the critical first step of questionnaire development is to conceptualize a precise target construct and its context. They found that writing a brief and formal description of the construct is very useful for this step.

**Table 1:** Categorization of mobile device interface elements (Ketola & Roykkee, 2001)

| Interface          | Category  | Items  |
|--------------------|---|--|
| User Interface     | Input tools (functionality, industrial and mechanical design) | Navigation tool, Softkeys, Keypad/Keyboard, Special keys (Power, Call management, Voice) |
|                    | Display   | Icons, Indicators, Language, Familiarity, Localization                                   |
|                    | Audio, Voices   | Ringling tones, Quality, Interruption  |
|                    | Ergonomics  | Touch and feeling, Slide, One-hand operation, Balance, Weight, Size                      |
|                    | Detachable parts  | SIM card, Battery, Snap-on (Color) cover   |
|                    | Communication method  | Radio link, Bluetooth, Infrared, Cable   |
|                    | Applications  | Fun, Utility, Usability  |
| External Interface | User Support  | Local help, Manuals, Documentation   |
|                    | Accessories   | Charger, Hands-free sets, Loopset, External keyboard                                     |
|                    | Supporting software   | PC software, Downloadable application  |
| Service Interface  | Services  | Availability, Utility, Interoperability  |

The target products are electronic mobile products, including mobile phones, smart phones, PDAs, and Handheld PCs that support wireless connectivity and mobility in the user's hand. The target components and interface features of mobile devices should also be specified, since the mobile devices are interactive systems involving users and service providers. As shown in Table 1, there are three different aspects of mobile device interfaces—the external interface, user interface, and service interface. To develop the questionnaire for usability of the mobile devices in

this research, the service interface aspects, such as availability of connection or service and interoperability were not considered. User interface components comprised the target construct, but the external interface which is defined in Table 1 also was regarded as important since documentation, such as manuals, is one of the essential parts of usability dimensions from the consumers' point of view according to Keinonen (1998).

The scope of the usability concept should be determined for the clarity of the target construct definition. The selected definition of usability is that established by ISO 9241-11: "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" (1998, p. 2). This definition was given to all the participants in this study to clarify what usability means. Based on the descriptive definition, aesthetic appeal (image or design) (Ketola, 2002; Kwahk, 1999) and emotional dimensions (Jordan, 2000; Logan, 1994) were added as important sub-dimensions, since the target products are consumer products not software products. The summary for the conceptualization of the target construct is provided in Table 2. This specification was referred to as the target construct throughout this study.

**Table 2:** The specification of target constructs for the questionnaire development

| Target Products       | Product Components | Scope of Product Usability            |
|-----------------------|--------------------|---------------------------------------|
| Mobile phones,        | User interface     | ISO 9241-11 definition                |
| Smart phones,         | External interface | Aesthetic appeal (image or design)    |
| PDA's, & Handheld PCs |                    | Emotional dimensions (e.g., pleasure) |

## 2.2 Creation of an Items Pool

Since the scope and range of the target constructs have been identified and an extensive literature review on the content domain has been performed in previous sections, the actual task of creating the items pool can be initiated. According to several guidelines for the development of questionnaire scales (Clark & Watson, 1995; DeVillis, 1991; Netemeyer *et al.*, 2003), the creation of an initial pool is a crucial stage in the questionnaire development process. The goal of this step is to sample all the potential contents and items that are relevant to the target construct. Because the subsequent steps in developing the questionnaire can identify weak and unrelated items that should be eliminated, the initial pool should be broad and comprehensive and include even items unrelated to the core construct (Clark & Watson, 1995; Loevinger, 1957).

The sources of the initial items pool include existing usability questionnaires surveyed (e.g., SUMI, QUIS, PSSUQ, PUTQ, and QUEST) and comprehensive usability studies for electronic consumer products (Keinonen, 1998; Kwahk, 1999) and mobile devices (About.com, 2003; Ketola, 2002; Szuc, 2002) as explored in the previous sections. Also, items for measurement of pleasure in using the product (Jordan, 2000), interface feature-based questions pertaining to critical features of mobile devices (Lindholm, Keinonen, & Kiljander, 2003), and typical tasks using mobile phones (Klockar, Carr, Hedman, Johansson, & Bengtsson, 2003; Weiss, Kevil, & Martin, 2001) were created and included. Thus, a total 512 questionnaire items were gathered as the initial items pool.

## 3 Study 2: Item Judgement and Content Validity

### 3.1 Design

First, the researcher conducted a redundancy analysis of the usability questionnaire items to eliminate redundant items. Then, review sessions for relevancy analysis were held. The panel of reviewers performed relevancy analysis of the questionnaire items. They selected relevant items for the target construct from among the set of questionnaire items identified through the redundancy analysis.

### 3.2 Participants

#### 3.2.1 Part 1

The participant for redundancy analysis was the researcher of this study. He is a Ph.D. student with 4 years of experience in HCI and usability engineering fields.

### 3.2.2 Part 2

Two of four expert reviewers were selected as subject matter experts who have worked extensively in usability engineering field and also have been involved in a multi-year project for the usability evaluation of mobile devices. Thus, the two experts were believed to have not only an extensive knowledge of general usability evaluation, but also an understanding of specific features and issues of mobile products usability based on their experience in mobile device projects. In this way, the reviewers could provide usability experts' point of view to select questionnaire items. However, these two experts have different educational backgrounds in terms of usability engineering so that the two experts may not have a strong bias driven by a usability engineering perspective from a specific education program. One was a Ph.D student at a university in Korea and the other was a Ph.D student at Virginia Tech in the U.S.

The other two reviewers were non-specialist users of mobile devices. This study adopted user profiles of four different types of mobile user groups (See Table 3). According to the definition of the four different user groups, a representative profile for each user group was provided. Thus, there were four non-specialist users of mobile devices in addition to the two experts. The non-specialist users outnumbered the experts with the intention of reducing the possibility of excluding potential items only from usability engineers' point of view. Table 4 summarizes the profiles of the participants for the relevancy analysis.

**Table 3:** Categorization of mobile users (IDC, 2003) quoted by Newman (2003)

| Label of Users          | Description   |
|-------------------------|---|
| Display Mavens          | Users who primarily use their devices to deliver presentations and fill downtime with entertainment applications to a moderate degree |
| The Mobile Elites       | Users who adopt the latest devices, applications, and solutions, and also uses the broadest number of them                            |
| Minimalists             | Users who employ just the basics for their mobility needs; the opposite of the Mobile Elite   |
| Voice and Text Fanatics | Users who tend to be focused on text-based data and messaging; a more communications-centric group                                    |

**Table 4:** Participants' profiles for relevancy analysis

| Participants                      | Description   |
|-----------------------------------|---|
| Expert #1                         | A Ph.D student trained for usability engineering in Korea   |
| Expert #2                         | A Ph.D student trained for usability engineering in US  |
| User #1 (Display Mavens)          | An entrepreneur who travels on flights and delivers presentations frequently  |
| User #2 (Mobile Elites)           | A male college student who adopts the latest high-tech devices such as camera-enabled cell phone, PDA, and MP3 player |
| User #3 (Minimalist)              | A middle-aged mother who needs short and frequent communication from work and home with family members                |
| User #4 (Voice and Text Fanatics) | A female college student who uses text messaging frequently among her group of friends                                |

## 3.3 Procedure

### 3.3.1 Part 1: Redundancy Analysis

The researcher conducted a redundancy analysis to reduce the number of identical items. The computerized card sorting method was used so that the researcher could pick one item from a stack of cards with keywords (window on the right) and compare it with other items to identify similar keywords, and place it in the category (window on the left) in which cards with similar keywords were stacked. The keywords were assigned previously to each item in the database by the researcher. The keywords were extracted or inferred from representative nouns or adjectives in each item and the titles of categorization, if any. For example, there was an item saying "This product responds too

slowly to inputs” from SUMI. The keywords would be *response*, *slow*, and *speed*. In addition, the item is categorized under the category of “efficiency” according to SUMI. Thus, efficiency is also added as a keyword for the item. After gathering similar items into a group, the researcher composed a revised questionnaire item (window at bottom) that was representative of the group. Once an item was placed in a group in the left window, it was removed from the potential list in the right window. By repeating this task, the revised non-redundant questionnaire items were compiled into the system.

### 3.3.2 Part 2: Relevancy Analysis

The panel of reviewers were given the target construct along with the selected definition of usability, “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” (ISO 9241-11, 1998, p. 2), and asked to conduct a relevancy analysis of each item. They were to determine if each item measured the target construct. Each participant completed the relevancy analysis session independently. Thus, they were not informed of the result of the relevancy analysis by the other participants. They were asked to rate each item as “very representative”, “somewhat representative,” or “not representative” of the target construct based on their own judgment. To assure inter-rater reliability in the rating by the reviewers, only the items that rated by at least four reviewers of the panel as very representative or somewhat representative were retained. Since there were four non-specialist users and two experts on the panel, we could still retain items that all the non-specialist users rated as very representative but both experts rated as not representative. If they thought that an item was partially representative of the target construct (e.g., only for mobile phone, not for PDAs), the participants could still select the item as “somewhat representative,” but designate the product to which it is exclusively relevant. Also, participants were asked to suggest any relevant but missing dimensions or items in the initial items pool.

## 4 Results

### 4.1 Part 1: Redundancy Analysis

After the redundancy analysis, the total number of items was reduced from 512 to 229, which consisted of 145 non-redundant items and 84 revised items that were combined from 367 redundant items. Thus, the content of each item appeared in some form an average of four times in the 367 items. Overall, about half of the items were redundant, since 512 items were reduced by about 50%. The most redundant item was, “Is it easy to learn to operate this product?” Table 5 shows the descriptive statistics of the number of redundant items according to the sources of the items.

**Table 5:** Summary of redundant items in the existing usability questionnaires used for the initial items pool

| Source of the Items | Original Number of Items | Number of Non-redundant Items | Percentage of Redundancy |
|---------------------|--------------------------|-------------------------------|--------------------------|
| 1. SUMI             | 50                       | 4                             | 92%                      |
| 2. PSSUQ            | 19                       | 0                             | 100%                     |
| 3. PUTQ             | 100                      | 35                            | 65%                      |
| 4. QUIS 7.0         | 127                      | 37                            | 71%                      |
| 5. QUEST            | 27                       | 5                             | 81%                      |
| 6. Keinonen (1998)  | 42                       | 6                             | 86%                      |
| 7. Kwahk (1999)     | 48                       | 15                            | 69%                      |
| 8. Jordan (2000)    | 14                       | 7                             | 50%                      |

As described in the table above, PSSUQ (100%) and SUMI (92%) have the highest percentages of redundancy with the other sets of questionnaire items. The total number of items in each set varies, so the level of detail in the items could be the reason for the variation in the amount of redundancy for each set. Since QUIS and PUTQ have the largest number of items, it is to be expected that they have a lower percentage of redundancy.

To investigate the redundancy analysis more closely among items across the sources of the questionnaire items, the frequency of each keyword across existing usability questionnaires was examined. As mentioned above, 367 items

were combined into 84 items. The keywords of the 367 items were examined. According to the examination, the most frequent keywords in the redundant items were related to consistency, helpfulness, learnability, usefulness, and clarity of physical features in abstract terms. The most frequently mentioned nouns or objects were documents, manuals, menus, color, speed, and error.

Another way of looking at the items in terms of redundancy would be the frequency of content words. One category of content words, adjectives in the existing questionnaire items, was counted without regard for redundancy. The existing questionnaire items include all the sources shown in Table 5. Since this investigation considers all the items in the questionnaires, a total 427 items was examined. The most frequent adjectives were easy (difficult), clear (fuzzy), consistent (inconsistent), and helpful (unhelpful). The most frequent nouns—as subjects or objects—in the questions were user, information, data, and screen. Table 6 shows the list of major words according to the word form.

**Table 6:** Frequency of content words used in the existing usability questionnaires

| Word form               | Words (Counts)  |
|-------------------------|---|
| Qualifying words        | Use (63), easy (55), provide (25), difficult (23), clear (22), consistent (21), confusing (13), helpful (13), looks (11), feel (10), adequate (9), required (9), simple (8), easily (8), distinctive (7), complete (7), inadequate (7), learn (6), operate (6), fast (6), inconsistent (6), unhelpful (5), slow (5), logical (5)  |
| Subject or object words | information (24), data (18), screen (17), commands (16), tasks (21), messages (13), help (13), control (13), feeling (12), menu (11), way (10), error (10), work (10), image (9), time (9), display (8), learning (8), entry (8), selection (8), ability (7), terminology (7), features (7), sequence (7), training (7), tutorial (7), reactions (6), feedback (6), speed (5), wording (5), options (5), instructions (5) |

\* Propositions, pronouns, and other particles were not counted.

Thus, when usability researchers and practitioners intend to develop and design their own usability questionnaires, this frequency list of the content words could be referred to as the foundation of composing questions or check list to diagnose usability problems. The possible combinations of the qualifying words and subject or object words in the table could create hundreds of item sentences.

## 4.2 Part 2: Relevancy Analysis

As the result of the redundancy analysis by the reviewers, the reduced sets of usability questionnaire items consist of 119 items for cell phones and 115 for PDA/Handheld PCs, while 110 items are shared for both mobile products. Thus, there are 124 total items combining both sets. Among the total 124 items, 65 items are items revised from redundant items and 59 are the non-redundant items. Since there were 84 revised items before the relevancy analysis, 77% (65/84) of the revised items were retained by the reviewers. The 59 items out of 145 non-redundant items constitute 41% (59/145) of the non-redundant items that were retained by the relevancy analysis. The item with the highest rating as relevant was, “Are the command names meaningful?”

In terms of the sources of the items, 85% (106/124) of the items are from the existing usability questionnaires and 15% (18/124) are from the sources other than the usability questionnaires. Once the reduced questionnaire items were finalized, each item was re-written to be compatible with a Likert-type scale response. The questions were revised to be structured to solicit “always” and “never” responses on a seven-point scale.

## 5 Discussion

As the result, six items were selected from the sources targeting to emotional dimensions. Among the image/impression dimension for consumer electronic products (Kwahk, 1999), only Shape and Harmoniousness were selected as the relevant items. According to the relevancy analysis scores, Texture, Translucency, Volume, Granularity, Luxuriousness, and Magnificence were the least relevant items among the items of the image/impression dimension. However, the other items such as Color, Brightness, Heaviness, Neatness, Preference, Satisfaction, Acceptability, Attractiveness, Comfort, Convenience, and Reliability were redundant with the items from other sources, so that these items were retained in other items from the result of relevancy analysis. Balance,

Elegance, Saliency, and Dynamicity were voted as the relevant items by a few participants, but the scores were not enough to retain them.

From another source of emotional dimensions of usability, Jordan's (2000) measure for product pleasurable, four items were selected as relevant. There was a total 14 items in the source measuring product pleasurable, and half of them were redundant with items in the other sources. There were 7 items non-redundant with any other items, and those were

- *I feel attached to this product\**
- *Having this product gives me a sense of freedom\**
- *I feel excited when using this product*
- *I would miss this product if I no longer had it*
- *I am proud of this product*
- *This product makes me feel enthusiastic\**
- *I feel that I should look after this product*

Among the items, the first, second, and sixth, all marked with asterisks, failed to be retained due to the lower scores of the relevancy analysis.

Among the 512 items of initial pool, 427 items were from the existing questionnaires and comprehensive usability studies for electronic consumer products as summarized in Table 5, and 85 items were from the sources other than the existing questionnaires. Among the 85 items that were not from the existing questionnaires, 23 items were retained through the relevancy analysis. Thus, the final set of questionnaire items after redundancy analysis consisted of 101 items from the existing usability questionnaires and 23 items from other sources related to mobile devices.

## 6 Conclusion

Based on the need for a usability questionnaire tailored to electronic mobile products, questionnaire sets for mobile phones and PDA/handheld PCs were developed. The definition of usability by ISO 9241-11 was used to conceptualize the target construct, and the initial questionnaire items pool were comprised of various existing questionnaires, comprehensive usability studies, and other sources related to mobile devices. Through the redundancy and relevancy analyses by representative users, total 124 items (119 for mobile phones and 115 for PDA/Handheld PCs) were retained from the 512 items of the initial pool.

The resulting questionnaire sets would be helpful for usability practitioners to employ in the comparison of competing electronic mobile products in the end-user market, evolving versions of the same product during an iterative design process, and selecting alternatives of prototypes during the development process. However, to increase reliability and validity of the questionnaires, follow-up studies employing psychometric theory and scaling procedures are under progress and will provide refinement of the items.

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