Information Systems Frontiers 7:2, 175–186, 2005

An Empirical Study of Use Contexts in the Mobile Internet, Focusing on the Usability of Information Architecture

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Abstract. *The mobile Internet—accessing the Internet via a mobile device—has become quite popular recently. The mobile Internet is mainly different from the stationary Internet because it may be used in various contexts, whereas the stationary Internet is mostly used in pre-determined environments. However, it is unclear when the mobile Internet is used most frequently, and in what context it is most useful. A greater understanding of the contexts for using the mobile Internet will relieve usability problems that mobile Internet users often encounter.*

This paper proposes a conceptual framework of use contexts, which includes various facets of contexts related to the mobile Internet. It then presents the results of an exploratory study in which the use contexts for the mobile Internet and corresponding usability problems have been empirically monitored. The results indicate that use of the mobile Internet is heavily clustered around a few key contexts, rather than dispersed widely in diverse contexts. Moreover, different contexts are found to cause different kinds of usability problems. The paper ends with theoretical and practical implications of the study results.

Key Words. *mobile Internet, context, information architecture, usability problem*

1. Introduction

The mobile Internet, defined as wireless access to the World Wide Web, allows people to use diverse Internet services anytime and anywhere via hand-held devices such as mobile phones or personal digital assistants (Federal Trade Commission, 2002; Francis, 1997). Use of the mobile Internet is spreading at an astonishing speed worldwide and is expected to surpass traditional use of the stationary Internet in only a few years (Merrill Lynch, 2000). For example, more than ten million people in Korea (25% of the total population) have acquired their own mobile Internet phones over a period of just a few years (Ministry of Information and Communication, 2000).

The mobile Internet is considered to be rather different from the stationary Internet in two important respects (Bhagwat and Tripathi, 1994). First, the mobile Internet can be used in various contexts, whereas the stationary Internet is mostly used in pre-determined environments. Due to the mobility and intimate connectivity of the mobile Internet, it can be readily used even on the road or in cars, whereas the stationary Internet has been used mostly in limited contexts such as an office or home (Rodden et al., 1998; Pascoe, 1998). Therefore, it is important to know in what contexts people use the mobile Internet, and also how often they use the mobile Internet in these contexts (Durlacher Research, 2000). However, not much research has been conducted to define available contexts for the mobile Internet, or to identify the key contexts in which people use the mobile Internet most frequently. Second, the mobile Internet usually comes with much more limited system resources than the stationary Internet (Bhagwat and Tripathi, 1994). For example, the mobile Internet has smaller screens, less convenient input devices, and slower networks. These limited resources tend to make the mobile Internet more difficult to use. Thus, overcoming usability problems is regarded as one of the most critical factors for the success of the mobile Internet (Creativegood, 2000). However, little is known about the major types of usability problems in mobile contexts, not to mention the impacts of diverse contexts on major usability problems.

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This study aims at empirically exploring key contexts and their impacts on usability problems in the mobile Internet. In order to achieve this goal, we first propose a comprehensive framework of mobile contexts and mobile usability problems. The following section of this paper explains the monitoring methods that were employed to capture the mobile contexts and usability problems accurately in our study. The subsequent section presents results from the monitoring study, followed by implications and limitations of the study results.

2. Mobile Contexts and Usability Problems

In order to understand the characteristics of the mobile Internet, we should know the contexts of its use and how the use of the mobile Internet can be affected by these contexts.

2.1. Mobile contexts

We define *mobile context* as 'any personal or environmental factors which may influence the *person* when he/she is using the mobile Internet'. Our definition of contexts has two characteristics. First, our definition focuses on the factors from the user's perspective, even though contextual factors can be theoretically limitless (Chávez, Ide, and Kirste, 1999). We are primarily interested in the contextual factors that may influence users' behavior, because our study aims at identifying usability problems that people often experience while using the mobile Internet. This definition is consistent with prior studies on contexts, in which contextual factors include only those that are interesting to target users—such as user tasks, user actions, and the specific situations of the users (Chávez, Ide, and Kirste, 1999; Chen and Kotz, 2000).

Second, our definition includes not only personal contexts but also environmental contexts. Personal contexts refer to factors relevant to people who are currently using the mobile Internet (Ebling and Satyanarayanan, 1998). For example, the emotional (joyful or depressed) and physical (moving or standing) states of the users are considered elements of personal contexts (Pascoe, 1998). On the other hand, environmental contexts describe the external circumstances of mobile Internet users (Dey, 2001). For example, location of use and number of nearby people are considered elements of environmental contexts (Schmidt, Beigl, and Gellersen, 1999). It is important to consider both personal and environmental factors, because recent mobile information applications have been developed not only to consider external factors that affect the use of mobile Internet services, but also to perceive and respond appropriately to the mental states of a user (Siewiorek, 2002). Based on our definition, we propose a structure of mobile contexts as shown in Fig. 1.

In Fig. 1, we first divided contextual information into two categories: personal context and environmental context. Personal context consists of internal and external contexts (Schmidt, Beigl, and Gellersen, 1999). Internal context refers to intrinsic aspects in the user's mind, that is, why he/she uses the mobile Internet and how he/she is feeling while using it (Healey and Picard, 1998). Therefore, the subcomponents of internal context include the purpose for using the mobile Internet (goal) and the state of feeling (emotion).

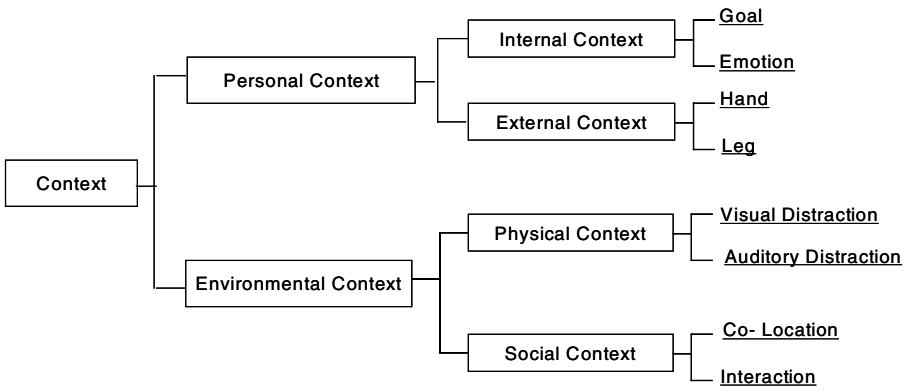


Fig. 1. *Context structure.*

In general, users' goals can be classified into two categories: utilitarian or hedonic (Dhar and Wertenbroch, 2000). Users with utilitarian goals pursue specific information, whereas those with hedonic goals surf while enjoying themselves without a specific purpose. Dhar and Werternbroch (2000) found that the utilitarian and hedonic dimensions were valid classification criteria for various products and services. Hoffman and Novak (1996) also classified into utilitarian and hedonic groups the benefits that users could gain from computer-mediated environments. The limited resources of mobile Internet devices and the various contexts of mobile Internet environments increase the importance of a user's goals (Schmidt, Beigl, and Gellersen, 1999). Hence, this study proposes user goals as an important contextual factor and in our framework of contexts classifies 'utilitarian' goals as instrumental benefits and 'hedonic' goals as experiential benefits.

The second subcomponent of internal context, emotion, is a multifaceted phenomenon that encompasses a diversity of processes such as appraisal, facial expressions, bodily responses, feeling states, action tendencies, and coping strategies (Philippot, 1993). The emotion of a user is an important contextual factor, because it induces action tendencies that may elicit certain behaviors (Spector and Fox, 2002; Bies, Tripp, and Kramer, 1997), such as the use of mobile Internet services. Schmidt, Beigl, and Gellersen (1999) and Gwizdka (2000) suggested emotion as one of the weighty contextual factors. One of the important subfactors of emotion is the level of pleasure (Mehrabian and Russell, 1974; Wirtz, Mattila, and Tan, 2000). Pleasure relates to the temporary physiological states and moods that a user brings to any activity—in other words, how much he or she is feeling joyful or depressed. Levels of pleasure are important contextual factors because they can direct a user's interactions with the mobile Internet. For example, Meon and Kahn (2002) argued that the user's level of pleasure can influence his or her online interaction behavior. For this reason, we include the users' level of pleasure in our framework, and code joyful emotion as 'high' and depressed emotion as 'low'. External context is related to the physical body of the user, and consists of two subfactors: hand and leg. The hand factor indicates the availability of the user's hands, i.e., whether one or two hands are available to manipulate the keypads of mobile devices (Kristoffersen and Ljungberg, 1999a). The availability of hands is an important contextual factor in use of the mobile Internet, because people usually hold their mobile devices while using mobile services and also because they are usually doing something else simultaneously (Kristoffersen and Ljungberg, 1999b). Therefore, we code 'one' in contexts where only one hand is available to use the mobile Internet, and 'two' when both hands are available.

The leg factor indicates the movement of the user, i.e., whether he/she is or is not moving through physical space (Gross and Specht, 2001; Kristoffersen and Ljungberg, 1999b). The mobile Internet user may move from one location to another during usage, as opposed to the stationary Internet user, who accesses the Internet from a single location (Ryu, Choi, and Kim, 2001; Kristoffersen and Ljungberg, 1999a). The ability to move while using the services is one of the most important characteristics of the mobile Internet, so we included the leg factor in our framework. We classify contexts as 'stopped' when the user is standing or sitting, whereas 'moving' is used to represent contexts where the user is moving around in a physical location.

As previously mentioned, the second contextual category in our framework is environmental context. Environmental contexts are composed of physical and social environments. Contextual factors related to the concrete physical aspects of the environment are classified under physical context, whereas those that are related to other people present are classified under social context. The physical aspects indicate the level of distraction in a given context, either visual or aural. Visual distraction means how much visual information is presented to the user, whereas auditory distraction refers to the degree of noise present while he/she is using the mobile Internet (Schmidt, Beigl, and Gellersen, 1999). Distraction is an especially important factor in a mobile environment, i.e., the distractions of walking, driving, and other real-world interactions often preoccupy users (Anhalt et al., 2001). Distraction is classified as 'high' when a user is highly distracted, and 'low' when a user is less distracted. The social context refers to how many people are near the user (co-location) and how much interaction he/she has with them (interaction) while using the mobile Internet. Co-location, or how crowded the user's immediate environment is, is important because it affects his or her perception of the restricted aspects of limited space (Harrell and Hurt, 1976). Seo and Jung (2000) showed that co-location influences the amount of time a user manifests a particular behavior. Studies of consumer behavior also suggest that the perceived degree of co-location can facilitate or obstruct desired behaviors (Hui and Bateson, 1991), such as the use

of mobile Internet services. Co-location is classified as 'high' when many people or objects surround a user, or 'low' in the reverse condition. Interaction refers to the degree of communication with other people surrounding the user. Whether or not the user is interacting with somebody else is an important contextual factor that can prohibit or foster the use of some mobile services (Kim et al., 2001). In the same vein, Schmidt, Beigl, and Gellersen (1999) presented social interaction as an important contextual factor. Interaction is classified as 'high' when the user is actively interacting with others, or 'low' in the reverse condition.

In summary, contexts include eight different aspects: goal and emotion for internal personal contexts, hand and leg for external personal contexts, visual and auditory distraction for physical environment contexts, and finally co-location and interaction for social environment contexts.

2.2. Mobile information architecture

One of the main goals of this study is to investigate the impacts of various contexts on the usability problems people experience while using the mobile Internet. We expect that different contexts cause different kinds of usability problems. In order to investigate this expectation, we first need a comprehensive framework to classify different usability problems into appropriate categories. In this study, we apply the framework of *information architecture*, which is a process of organizing, labeling, and designing navigation and searching systems that helps people find and manage information more successfully (Rosenfeld and Morville, 1998). Information architecture has been shown to be an effective framework to enrich customers' experiences on the stationary Internet (Garrett, 2002; Wodtke, 2002). We extended this conceptual framework to the mobile Internet in order to categorize the problems users experience. Mobile information architecture consists of four elements: representation, structure, navigation, and content. First, representation refers to the visual presentation of information (Kamba et al., 1996). It consists of several aspects, such as how efficiently the information is shown on the LCD panel of mobile devices, how easy it is to read the presented information, and how compactly information is presented to the users. The representation aspect is especially important in use of the mobile Internet because of the small screen size of mobile devices and the diverse situations in which the screen is viewed. The second element, structure, refers to how well the mobile Internet service is organized. It includes subcomponents such as the relevance of menu categorization, the appropriateness of menu labels, and the adequacy of the order of menu sequence. The structure aspect of the mobile Internet is very important because the large amount of information on the traditional Internet needs to be organized efficiently so that people can make the best use of mobile Internet services. Third, navigation indicates how efficiently the procedures of mobile Internet services are designed. The subcomponents of navigation include how easy it is to learn the procedure, how easy it is to move between different sub-services, and diversify, i.e., move to other than current services. The navigational aspect of information architecture is important for the mobile Internet because the input facilities of mobile devices can be awkward, making navigating very difficult. Finally, content means the relevance of information provided within particular contexts. Subcomponents of content include how effectively the information is given, how reliable it is, and how often it is updated. The content aspect of information architecture is important in mobile Internet use because different contexts may make some contents more relevant than others.

In summary, the mobile Internet can be used in various contexts in terms of the eight elements of the context structure (goal, emotion, hand, leg, visual, auditory, co-location, and interaction). In addition, different contexts may cause different kinds of usability problems that can be classified into four groups based on the framework of information architecture (representation, structure, navigation, and content).

3. An Empirical Study

An empirical study was conducted in order to collect detailed data about mobile contexts and usability problems.

3.1. Study procedure

The participants were recruited with a promise of monetary compensation through an advertisement on several Korean websites. More than 200 people applied for the study, and forty were selected initially, based on two criteria. First, all the participants were required to have sufficient experience using the mobile Internet prior to the study. Since we like to monitor the use of the mobile Internet in diverse contexts, heavy users who have adequate experience using the mobile Internet and who

use it in various contexts were selected. Second, participants were asked if they were able to use the stationary Internet to report their mobile Internet use during the study. Only those who could use the stationary Internet fluently were included.

Next we held a training session in which participants' tasks were explained in detail and a brand-new Internet phone was distributed to each. The phone was a mobile Internet-enabled cellular phone (Model IM-1200, made by SK Teletech), sized $107 * 42 * 20$ mm, with a standard cellular phone keypad, a black and white screen, and an 8×4 character screen. We also got written consent from the participants, which allowed us to access their usage data, as saved in the gateway servers of telecommunication companies. Following the training session, we conducted a three-day warm-up session, after which three participants who could not follow the instructions were excluded from the study. Consequently, thirty-seven people participated in the study. Their ages ranged from the teens to the forties; the average was 23.1 years. Their gender was fairly evenly distributed, with 57.8% female. They also had diverse occupations, ranging from high school students to professionals such as lawyers. Therefore, the composition of this participant pool was well-balanced in terms of age, gender, and occupation, in order to minimize the selection bias of participants.

The main study was conducted over two weeks in Korea. During this time, participants were encouraged to use the mobile Internet whenever they liked; their usage fees were reimbursed with some extra incentives. In addition to using the mobile Internet, they were instructed to perform two further tasks. First, they were asked to carry a pocket diary and fill in forms whenever they used the mobile Internet. The diary was designed to be used as a mnemonic aid, and was convenient and light to carry. The forms were similar in size to the mobile phone distributed to each participant, and the number of questions on each form was minimal. An image of the pocket diary is presented in Appendix 1. Second, participants were asked to connect to our web site at least once a day, and rewrite on the web diary what they had previously written in the pocket diary. The forms in the web diary matched those in the pocket diary, except that participants were also asked to write in detail about usability problems if they experienced any during a specific session.

At the end of each day, independent inspectors examined the web diary of each participant along with the server log data from the telecommunication companies. If any inconsistency was observed between the web diary and server log, the inspectors sent a text message to the corresponding participants requesting modification. Before beginning an actual monitoring study, we notified all the participants about the checking process, and only those who agreed to the monitoring participated in the main study.

After completing the monitoring study, we compensated the participants for their efforts with 200 USD as a base rate. In addition to the base rate, those who used the mobile Internet regularly and reported their usage correctly during the main study period received an extra 150 USD. All who participated in the main study faithfully followed the rules, and thereby received the maximum benefits.

3.2. Analysis procedure

The contents of the web diaries were analyzed in two parts: use contexts and usability problems. To investigate the use contexts of the mobile Internet, the eight context factors were posed directly to the participants in each session in the form of a questionnaire, presented in Appendix 2. This questionnaire was initially based on prior literature on mobile contexts (e.g Kim et al., 2001), and revised further based on participants' comments during the three-day warm-up session.[3]

In terms of goals, participants were to choose either a utilitarian or hedonic one, according to their purpose. For example, if they used the mobile Internet for pleasure, in activities to kill time, for instance, they were to select 'hedonic'. On the other hand, if they had specific goals in mind, they were to select 'utilitarian'. In terms of emotion, they were to select either 'high' when they felt joyful or 'low' when they felt depressed. As for external personal context, participants were to choose 'two' if both hands were available for using the mobile Internet, or 'one', if only one hand was available at that time. They were to select 'moving' if their legs were moving while using the mobile Internet; otherwise, they were to select 'stopped'. In terms of visual distraction, they were to choose 'high' if they observed lots of visual stimuli, and 'low' otherwise. In terms of auditory distraction, they were to select 'high' if they heard loud noises around them, and 'low' if their surrounding environment was quiet. In terms of co-location, they were to choose 'many' if they were surrounded by many people, and 'few' otherwise. In terms of interaction, they were to select 'high' if they communicated with other people around them while using the mobile Internet, and 'low' otherwise. In

summary, each of the eight context factors was coded in a bi-polar way, consequently producing a total set of 256 different contexts (2^8).

In terms of coding usability problems, the participants were asked to describe in detail any usability problems they experienced while they were using the mobile Internet services. Two coders were recruited to classify independently the written comments of participants into the four groups of the mobile information architecture framework. The coding schema for usability problems are presented in Appendix 3. For example, one of our participants commented, "*I was trying to find the location of the Hyundai department store, but strangely enough it was under the wrong menu category of Chatting*." This comment was coded into the usability problem category 'structure' because the information was located in the wrong place. In order to ensure the inter-coder reliability of encoding usability problems, the Kappa ratio was calculated as 0.79, which is good enough for conducting further analyses. The discrepancies between the two independent coders were reconciled after discussion before any further analysis.

4. Results

This section provides basic information on the monitoring data that were collected during the main study, followed by the results on the mobile contexts and usability problems that participants experienced most often in specific contexts.

4.1. General results

For 2 weeks, participants used the mobile Internet 61 minutes on average every day. Usage time ranged from a minimum of 7 minutes to a maximum of 132 minutes per day. During the study period, participants reported a total of 1552 sessions in the web diary. The number of sessions varied between 23 and 132, and each participant completed 42 diary entries on average. In total, 1505 usability problems were reported, an average of 41 problems per participant.

4.2. Use contexts

The entire set of 1552 sessions was classified according to the 256 different contexts, the results of which are shown in Fig. 2. The most important fact that we can infer from Fig. 2 is that the use of the mobile Internet was highly concentrated in a few key contexts. This is

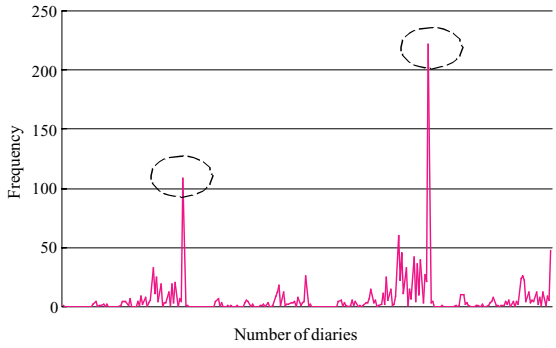


Fig. 2. *Frequently experienced mobile contexts.*

contrary to the general belief that the mobile Internet is used widely in diverse contexts. Two results shown in Fig. 2 support the fact that the mobile Internet is used heavily only in a few key contexts.

First, Fig. 2 shows that participants used the mobile Internet especially often in two specific contexts. The most frequently experienced context accounts for 222 sessions (14.6%), and the second most frequently experienced context accounts for 109 sessions (7.1%) among the entire 1552 sessions. Therefore, these two contexts, which are only 0.4% of the entire 256 possible contexts, accounted for more than 20% of all the sessions. Furthermore, only 14 (2.8%) of the 256 contexts made up more than 50% of all 1552 sessions.

The most frequently experienced context was as follows: participants had a hedonic goal, their emotional state was high, only one hand was available, their legs were stopped, visual and auditory distractions were low, few people were around them, and their interaction was low. The second most frequently experienced context is the same as the first, except the participant's goal was utilitarian rather than hedonic. Therefore, people used the mobile Internet most frequently when they felt joyful, had only one hand available for use, and were alone in a quiet and calm environment such as bedrooms or private offices. This is a somewhat different picture from the widely held belief that the mobile Internet would be used often while moving outdoors.

Second, Fig. 2 indicates that there are many contexts (99 out of 256, which is 38.7% of the entire set) in which participants never used the mobile Internet during the entire study period. This means that none of the 1552 sessions was used even once in these contexts. Table 1 presents the results for each context factor where the mobile Internet was used at least once. For each of the eight context factors, a standard *t*-test was

Table 1. *Mobile Internet case ratio*

Context factor		Used at least once (%)
Goal**	Hedonic	69.5
	Utilitarian	53.1
Emotion	Low	60.2
	High	62.5%
Hand***	One	76.6
	Two	46.1
Leg***	Stopped	85.9
	Moving	36.7
Visual	Low	57.8
	High	64.8
Auditory**	Low	53.9
	High	68.8
Co-location	Low	67.7
	High	60.9
Interaction	Low	68.0
	High	62.5

($^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$).

conducted to identify which context factor was closely related to the decision to use or not use the mobile Internet.

As shown in Table 1, context factors such as goal, hand, leg, and auditory distraction have significant impacts on use of the mobile Internet. For example, participants used the mobile Internet at least once in 109 out of 128 contexts (85.9%) while they were not moving ('stopped'). On the other hand, they used the mobile Internet in only 46 out of 128 contexts (36.7%) while they were moving. Therefore, participants used the mobile Internet statistically more often when they were not moving than when they were moving. Likewise, participants used the mobile Internet more often when they had hedonic goals (69.5%) rather than utilitarian goals (53.1%), when they had only one hand available (76.6%) rather than both hands (41.1%), and finally when they were in a noisy (68.8%) rather than quiet environment (53.9%).

In summary, the mobile Internet has been used heavily in a few key contexts, and these contexts are different from those previously assumed. Four of the eight context factors were found to have significant impacts on the use of the mobile Internet.

4.3. Mobile usability problems

We adopted the information architecture framework in order to study the usability problems endemic to the mobile Internet. For the analysis of usability problems, we selected thirty-eight of 256 contexts in which participants in the study used the mobile Internet more than ten times. We selected these contexts, which represented 75% of the entire data set, in order to minimize the bias from extreme data. We then calculated the average probability of specific usability problem types for each of the eight context factors. The results are shown in Table 2 below. For example, 18% in the upper left cell (Hedonic-Representation) in Table 2 means that 18% of all the usability problems that occurred when participants used the mobile Internet with a hedonic goal were representation problems.

Table 2. *Mobile Internet usage and problem ratio*

Context factor		Representation (%)	Structure (%)	Navigation (%)	Content (%)
Goal	Hedonice	18	14.0	27.0	40.0
	Utilitarian	19	16.0	31.0	34.0
Emotion	low	19	15.0	26.9	38.7
	High	17.9	14.6	29.5	38.0
Hand	One	17.9	16.5*	28.5	37.3
	Two	20.4	7.4*	29.6	42.6
Leg	Stopped	17.4**	14.8	28.6	39.3*
	Moving	35.1**	14.9	30.4	19.6*
Visual	Low	16.9	14.3	30.0	38.9
	High	19.6	15.1	28.5	38.4
Auditory	Low	19.4	13.7	28.6	38.1
	High	17.7	15.4	28.7	38.2
Co-location	Low	16.6	13.5	26.5	43.6**
	High	20.8	16.6	31.7	30.9**
Interaction	Low	17.5	14.3	30.2	38.0
	High	21.5	16.6	22.9	39.0
Average***		19.7%	14.6	28.7	37.2

($^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$).

The results in Table 2 indicate two interesting facts regarding usability problems of the mobile Internet. First, the averages of the results at the bottom of Table 2 indicate that the probability of occurrence was significantly different among the four different usability problem areas ($F = 40.44$, $p < 0.001$). Usability problems related to the content of the mobile Internet occurred most frequently (37.2%), followed by navigation issues (28.7%), representation difficulties (19.7%), and structure problems (14.6%). These results might indicate that the most severe problem in current mobile Internet services is a lack of appropriate contents that take into account key characteristics of the mobile Internet. Navigation problems might also occur more often because the small display area and awkward input facilities of mobile devices can make browsing the mobile Internet very difficult.

Second, a standard t-test was conducted for each of the eight context factors, to investigate the impact of contexts on the occurrence of specific types of usability problems. The results indicate that usability problems were significantly affected by three context factors: hand, leg, and co-location.

In terms of how many hands a user had available, structure problems were more likely to occur when participants used the mobile Internet with one hand (7.4%), compared to two hands (16.5%) ($t(30) = 2.16$, $p < 0.05$). In terms of whether or not they were moving, representation problems occurred more often when participants were moving (35.1%) rather than stopped (17.4%) ($t(35) = 2.63$, $p < 0.05$). By contrast, content problems occurred more often when participants were stopped (39.3%) rather than moving (19.6%) ($t(35) = 2.47$, $p < 0.05$). Finally, in terms of co-location, the participants experienced content problems more often when they were alone (43.6%) rather than when many people were present (30.9%). ($t(22) = 3.11$, $p < 0.01$).

In summary, people experienced different usability problems more often in certain contexts. They experienced more structure problems when they used the mobile Internet with one hand, more representation problems when they were moving, and more content problems when they were standing alone in a remote place.

5. *Conclusions and Discussion*

This study focuses on use contexts of the mobile Internet and their impacts on the occurrence of usability problems. The results of the study indicate three important findings in terms of mobile contexts and usability problems. First, people do not use the mobile Internet in every possible context, but their usage is heavy in a few critical contexts, such as when they are not moving and have only one hand available. Second, the type of goals that people have in mind, the availability of their hands, the movement of their legs and the level of auditory distraction have significant impacts on their use of the mobile Internet. Finally, different usability problems are experienced more often in certain use contexts. Availability of hands, movement of legs and number of people around the user were found to have especially significant impacts on the kinds of usability problems.

The results of this study have several limitations. First, participants in this study were asked to describe their use contexts using bi-polar responses. We used bi-polar measures in order to provide the participants with the simplest means of answering context-related questions. Asking participants to report too many items may discourage them from using the mobile Internet altogether. However, in order to provide more concrete suggestions to the developers of mobile Internet services, future studies should focus on a few context factors with more refined numeric measures. The second limitation of this study arises from its methodology. Even though we could infer relations between contexts and usability problems, we cannot explain why certain usability problems occurred more frequently in certain contexts. In order to provide causal explanations, more controlled experimental studies focusing on key usability problems should be conducted in the future.

Finally, the study results cannot be applied directly to the situation in other countries because all participants in the study were recruited in Korea. Moreover, thirty-seven people participating over two weeks might not be a large enough sample or time frame in which to collect comprehensive data on mobile Internet contexts and usability problems, although participants were balanced in terms of age, gender, and occupation. A future study may be conducted with more people in different cultures, over a longer period of time, to verify the external validity of the study results.

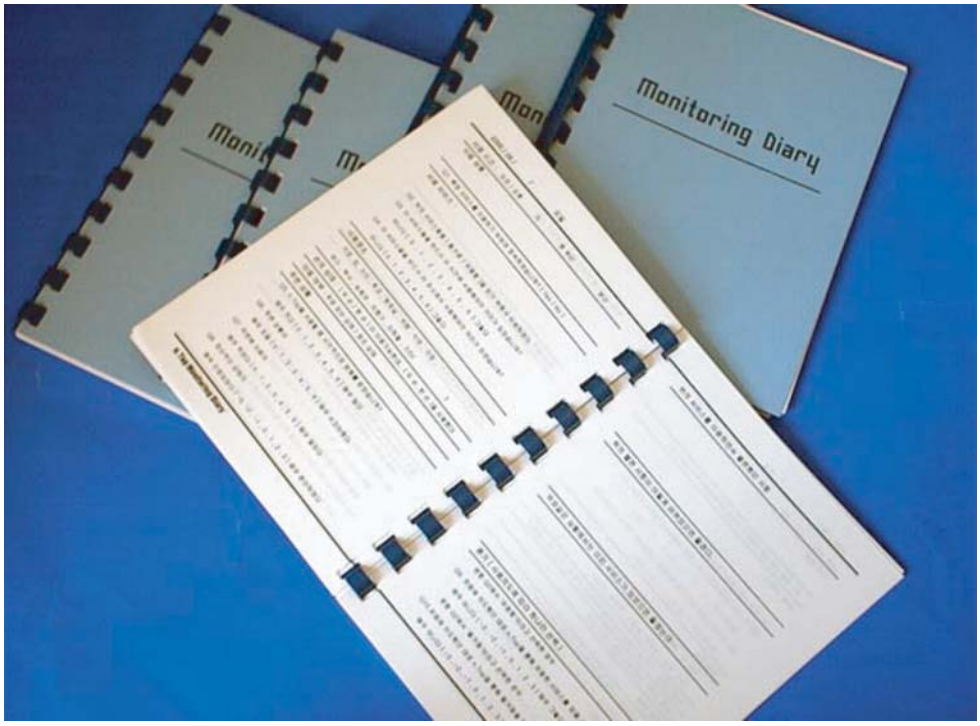
Despite these limitations, the results of this study have several implications from both the theoretical and practical perspectives. From the theoretical perspective, this study provides a conceptual framework of use contexts and usability problems in the mobile Internet. The contextual factors in our framework had been suggested based on prior research and were indeed found

during the study to be relevant. This study also presents a method that can collect reliable data about contexts and usability problems in the mobile Internet. The data collection method enabled us to amass 1552 usage sessions over two weeks. The validity of the self-reported information was verified by the objective log data from the gateway servers. Therefore, the method provides us with a rich and reliable data set about the contexts and usability problems of the mobile Internet.

From the practical perspective, the study results indicate that the mobile Internet is used heavily in a few contexts. This result implies that it might not be necessary to consider all the contexts of users in developing new mobile Internet services. Instead, in order to improve such services, developers might focus on the key context of mobile Internet use first, and then extend the scope to other contexts that have not been experienced as frequently. Moreover, in order to identify usability problems, usability testing in the key contexts is recommended in the process of developing new mobile Internet services. In particular, the results of this study might be important to companies that are developing context-dependent mobile services (such as location-based services) because it identifies key contexts in which people are using these services (Gessler and Jesse, 2001).

Moreover, people experience different usability problems in different contexts. For example, participants were found to experience more structure-related problems when they had to use the device with only one hand. This might be because scrolling the menu bar or changing pages by pushing the small buttons on mobile devices can be difficult to accomplish with one hand. Therefore, comprehensible menu categorizations and labeling systems should be provided for clearer understanding of mobile Internet structure for those applications that will be used with only one hand. In another example, users were found to experience more representation problems when they were moving. This might be because it is especially difficult for people who are in motion to read or see what is represented in the mobile phone's small display area. Therefore, developers of mobile Internet services that are expected to be used heavily while users are moving, as when they are trying to locate nearby shops, for example, should pay extra attention to facilitating representation.

Appendix 1. Pocket Diary



Appendix 2. Questionnaire

No.	Questions and Answers
1	Q: Why did you use the mobile Internet service? A: Utilitarian (if you used it for instrumental purposes)/Hedonic (if you used it for experiential purposes)
2	Q: How did you feel while you were using the service? A: High (if you were joyful)/Low (if you were depressed)
3	Q: How many hands were available when you were using the services? A: Two (if both hands were available)/One (if only one hand was available)
4	Q: Were you moving around or stationary when you were using the services? A: Stop (if you were stationary)/Moving (if you were moving)
5	Q: Were you visually distracted when you were using the services? A: High (if you were distracted)/Low (if you were not distracted)
6	Q: How noisy was it around you when you were using the services? A: High (if it was noisy)/Low (if it was quiet)
7	Q: How many people were around you when you were using the services? A: High (if there were many)/Low (if there were few)
8	Q: How much interaction did you have with those around you? A: High (if you interacted with them)/Low (if you did not interact)
9	Q: Please tell us in detail if you experienced any usability problems while you were using the services.

Finally, content-related problems were found to occur most frequently among the four groups of usability difficulties. These problems were especially serious when participants were not moving or were alone. This might be because most current mobile Internet services were developed focusing on mobility, whereas too few services are available that provide users with enough value when they are not moving. These results also indicate that content on the mobile Internet may not be sufficient or adequate for use when a user is alone in a remote place.

Therefore, mobile Internet services that are developed specifically for a specific context should pay extra attention to those factors that are closely related to the frequently-occurring usability problems in that context. This in turn may increase the overall satisfaction of mobile Internet users.

Appendix 3. Coding Schema for Usability Problems

Type	Questions
Representation	Was the image too small or too large? Was the text too small or too large? Was the information difficult to read? Was the representation not appropriate for mobile devices?
Structure	Was the classification of information wrong? Was the labeling of information incorrect? Was the procedure explained in the wrong place?
Navigation	Was the structure not appropriate for mobile devices? Did you get lost? Was it difficult to move around from one page to another? Was it difficult to identify your current location? Was the navigation facility not appropriate for mobile devices?
Content	Was the content up to date? Was the content useful for mobile users? Was the content rich and full of variety? Was the content not appropriate for mobile devices?

Acknowledgments

The present research has been supported by a research grant of the Asan Foundation in 2002. The authors express their appreciation to members of the Human-Computer Interaction Lab at Yonsei University and Widerthan.com for their comments on this paper.

Notes

1. The Mobile Internet can be defined in many ways. In the broad sense, the mobile Internet can include any wireless access to the Internet, including wireless LAN, wireless data technology (e.g., SMS) and wireless Internet (e.g., NTT Docomo). In the narrow sense, the mobile Internet refers to mobile Internet services accessed only through the mobile network (e.g., GSM). This study adopts the narrow definition of the mobile Internet, because it is practically impossible for users to access the traditional stationary Internet via mobile devices (e.g., mobile phone) or to access mobile Internet services from desktop computers. Therefore, for example, the accessing of the traditional Internet through the wireless LAN (802.11b) of notebook computers is not considered in our study. However, the study results are expected to be applied to mobile Internet services in the broad sense with supporting studies in the future.

2. Detailed information about the phone is available at www.skteletech.co.kr.
3. Since the study was conducted in Korea with Korean users, all the questions were originally written in Korean and translated to English for this paper.

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