

User Interface Context of Use Guidelines for Mobile Apps

Hana Al-Nuaim

*Faculty of Computer and Information Technology/
Computer Science Department/
King Abdulaziz University
Jeddah, 21589, Saudi Arabia*

hnuaim@kau.edu.sa

Lulwah Al-Harigy

*Deanship of e-Learning and Distance Education/
e-Learning Programs Department/
King Abdulaziz University
Jeddah, 21589, Saudi Arabia*

lalharigy@kau.edu.sa

Abstract

Due to the intensive use of mobile devices and the variable context of use, mobile apps user interface guidelines that take into account users' context of use is in urgent need to provide users with a good user experience while on the go. The objective of this paper is to propose context of use mobile user interface design guidelines and test their applicability on the design of a mobile version of an environmental e-government website. We collected a group of user interface design guidelines from different sources in the literature and linked them to the appropriate context of use, while some guidelines were linked to more than one context of use. An expert user, with no design experience used the proposed guidelines to design the mobile app. We conducted usability tests of the mobile app using two methods of testing: performance measurements and subjective measurements. To perform the performance measurement, we gave nine tasks to each of the 15 users and gave two questionnaires to each user to perform the subjective measurement. The results showed the following: the mobile app that was designed using the proposed guidelines—which the users tested while moving between different simulated environmental conditions—performed tasks in a similar time to the expert. This finding supports the applicability of the proposed guidelines in terms of designing mobile apps that will provide users with a good user experience. Thus, the proposed guidelines for designing a context-aware mobile app user interface were useful for producing a good user experience using the mobile app.

Keywords: User Interface Design, Contextual Design, Human Computer Interaction (HCI), Context Aware, Context of Use, Mobile User Interface Guidelines, Mobile Apps.

1. INTRODUCTION

The past couple of years have witnessed an exponential growth in the use of smart phones and their applications for different purposes. The always-on nature of mobile phones, the ability to communicate anytime and from anywhere, and the continuously increasing support features that are available mean that these devices are able to provide the critical information users need in emergencies. Mobile devices have expanded in functionality from being merely a device that dials numbers to being a personal digital assistant. In comparison to laptop computers, they are smaller, cheaper, and continuously improving. Furthermore, their features allow users to use take advantage of them during many of their transactional daily activities in many areas such as learning, services, security, and banking [1]. The mobility of telecommunications and the support of many communication services are two distinct advantages of mobile communication devices [2].

Although one of the biggest challenges in designing a mobile version of a website is the context in which it will be used, developers sometimes ignore the fact that users will want to interact with such devices while on the move [3]. As mobile devices are designed to enable users to use them while

mobile, the ability to use a website while mobile is a critical factor in its success or failure, especially for websites that have important information and must be used accurately [3]. Some of the issues that need to be considered when designing for small, portable devices are small screen sizes, limited connectivity, high power consumption rates and limited input modalities [3].

Web use on a mobile device is different than Web use on a desktop computer because the goal for designing mobile versions is to downscale the full version of a website to fit the mobile screen and decide which content, services, and functions to keep from the desktop website [4]. The effectiveness and benefits of mobile phone technologies has exceeded expectations, and the need for designing mobile versions is increasing due to the fact that the different contexts of use that occur while using them are affecting their usability [4]. Although the mobile devices and wireless technology are being upgraded, providing a variety of functionalities, Web browsers try to solve interaction problems that occur when small-screen devices are used to access Web pages designed for large screens. Browsing large Web pages is not adapted for small-screen viewing and is still very inconvenient [5]. The small display size of mobile devices limits their ability to transmit information effectively in comparison with desktop computers regardless of the increasing quality of displays [5]. The user interface is one of the most important parts of any program because it determines how easily you can make the program do what you want [6]. A well-designed and usable mobile-versions interface is critical since mobile-device interface design is more restrictive than desktop interface design. The most challenging problems facing mobile interface designers include [7]:

- constantly changing context of usage;
- limited user attention given to the device and application;
- mobile device user's hands are typically occupied with other physical tasks;
- high mobility during tasks as well as the need to adopt a variety of positions and postures; and
- interacting with devices while in motion (at high speed), driven by the external environment.

2. CONTEXT AWARENESS

Dey and Abowd (2000) defined context as: "Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves."

There are many types of context such as location, identity, activity (or environment), and time [8]. Context includes lighting, noise level, network connectivity, communication costs, communication bandwidth, and even the social situation [9].

Context-awareness is often defined in relation to an application or a computational service, which includes the ability to detect and sense or to interpret and respond to the characteristics of a user's local environment [10]. It is also defined as a state where the device is aware of the situation in which it is being used [11]. Context-aware applications look at the who's, where's, when's, and what's of the entities and then use the information to determine why the situation is occurring [8]. This technology has gained an increasing amount of attention in recent years; it may offer solutions to more efficient use of mobile applications and services while the increasing complexity and growing number of features set challenges to intuitive and easy-to-use devices [11]. It has appeared as an important and eligible feature in distributed mobile applications, which deal with the ability of applications to exploit information about the user's environment (context) in order to dynamically select and execute relevant services that better match the user's needs [12].

A context-aware device can infer the use condition, and adapt its behavior according to the circumstances [11]. Mobile handheld devices constitute an interesting platform for context-awareness because they have been highly adopted by large user groups especially in the form of

mobile phones [11]. They are used in different kinds of situations, different users' preferences, and different prioritized features [11].

Context awareness can facilitate the device's use in demanding situations by dynamically adapting the devices' behavior by appropriate means [11]. In short, context-awareness aims to provide users with better services and adapt the behavior of the device by using and handling the contextual information.

Exploiting the changing environment with a new class of applications that are aware of the context in which they are running is one challenge of mobile distributed computing [9].

The context of use of the mobile devices has deep effects on interaction when considering users on the move, instead of users using devices (mobile or not) while sitting at a desk in their office or home. These effects show at different levels [13]:

- Perceptual: there are physical parameters of the mobile user's environment, such as illumination, noise, temperature and humidity, vibration and motion, etc., which are extremely variable, limiting, and can exclude one or more modalities.
- Motor: mobile conditions can harm a user's ability to control her/his controlled movements or take specific attitudes (e.g., standing) that interfere with motor operation of the device (e.g., time and errors in selecting options and the effectiveness of using writing recognition or gesture recognition software).
- Social: even when using specific forms would be perfectly possible from a perceptual and motor point of view, social norms related to different environments may make it impossible or unadvisable. For example, keeping sound on at a conference is not accepted, while looking at the device screen is accepted.
- Cognitive: unlike the office and home environments, people in mobility conditions can apply only very limited attention to interact with applications on the device because they have to focus on a constant flow of events and stimuli that come from the environment. Some of these events can affect personal safety (e.g., noticing potential dangers while users are in a street).

According to Al-Nuaim (2014), the challenges of the context-aware issues that designers face can be categorized into three groups:

- the mobile device and user behavior while using it;
- the usability of the mobile website design; and
- the user interaction with the mobile website.

Therefore, the general needs of a context aware system are [14]:

- context acquisition: how to obtain the contextual information;
- context representation: how to organize and store the context information; and
- context use: how to use the context information in an appropriate manner.

Content adaptation is a key part in the process of designing applications because we have to adapt the content presentation to meet the user preferences and the different capabilities and limitations of mobile devices and wireless technologies that are used by different users [15].

A user interface designed for a mobile device is the main concern in designing applications [16]. While there has been success in developing rules to guide the design and implementation of interfaces for desktop machines and their applications, the design of mobile device interfaces is still relatively unexplored and unsupported [17]. Many public and private entities design mobile apps of their websites without basing their design decisions on powerful design approaches because there is a lack of research concerned with finding guidelines, practices, and recommendations for designing usable mobile apps [4].

There are many user interface design guidelines available within the literature for designing mobile apps but they do not address or are not linked well to context of use. We need clear and easy to apply design guidelines for mobile apps to maintain a good user experience for users when they use their devices while on the move and in different environment conditions; especially if they use the app in urgent situations or need critical information for their safety.

Due to the intensive use of mobile devices and the variable context of use, mobile apps user interface guidelines that take into account users' context of use is in urgent need to provide users with a good user experience while on the go. The objective of this paper is to propose context of use mobile user interface design guidelines and test their applicability on the design of a mobile version of an e-government website (Presidency of Meteorology and Environment) in the Kingdom of Saudi Arabia.

Due to the mobile devices properties, which differ from the desktop counterpart, such as being small, desktop websites are altered to fit a mobile's small screen. If they are left unaltered, this will lead to scrolling up and down or right to left. Therefore, there is urgent need for mobile apps design guidelines to adapt the websites within displayed mobile devices. The lack of the research in mobile web design guidelines made it necessary to collect guidelines from the literature that can address the context of use and design mobile apps that provide users with a good user experience while mobile.

According to [18], there are some attributes of usability that should be considered:

1. **Learnability:** It refers to how easy is the website for users to accomplish basic tasks the first time they encounter the design so that the user can rapidly start getting work quickly with it.
2. **Efficiency of use:** Ease of the website means how much time and effort is required for users to achieve their objectives when using the website.
3. **Memorability:** It means is it easier for the users to navigate the website next time if they have visited the website before because of their previous experience.
4. **Low Error Rate:** It refers to how many errors do users make, how severe are these errors, and how easily can they recover from the errors.
5. **Subjective Satisfaction:** It means how do users feel about their interaction with the website, how much do they like using the it and will they return to the website or not.

3. CONTEXT OF USE

Mobile apps have different menu hierarchies, smaller sizes, and fewer images than their desktop counterparts [18]. Such design choices are necessitated by the characteristics of the client device, such as small screen size, limited input capabilities, and limited Internet connection speed, thus potentially leading to increasing usability problems [18] [19].

The characteristics of locations where the mobile phone use may take place, such as home, work, on the move, alone or with others may include several types of distractions like background noise, ongoing conversations, cars and people that pass by, and so on [20]. These distractions require the user's visual, auditory, and/or cognitive resources, which are also necessary for the mobile web-browsing task [20]. The competition between the task that the user will do and the distractions may reach a point where the user's awareness, memory, and attention resources are overloaded, thus decreasing user performance and, hence, the usability of the Web-browsing tasks [20].

Context of use must contain the characteristics of the intended users, the tasks users will perform, and the environment in which website visitors will use the system [21].

Juha et al [22] have developed the project "Kontti – Context-aware services for mobile users". The project was part of the "NETS Networks of the Future" research program run by the National Technology Agency of Finland (Tekes). Kekes and VTT Information Technology financed the project with three companies: Nokia, Radiolinja and Teamwave [22]. The results of the Kontti

project indicated that the most promising applications for context-aware services are event guides and professional use [22]. Further, contexts can be used for opening new communication channels for messaging and as a mediator where any recipient can pick up a public message [22].

Jesper and Jeni [23] have outlined an ongoing research activity into the challenges of interaction design for context-aware mobile computer systems. They have proposed the concept of indexicality as an interesting new approach to the interaction design for this emerging class of mobile systems, and have outlined three examples of context-aware prototype systems where this concept has been deployed in practice and evaluated through user studies [23].

The key requirement to develop and deploy a Context Aware Mobile Government Application is presented by Ariza Avila [14]. The Context Management application was developed using open standards to communicate with other applications. A real scenario in Vila Nova de Cerveira was also modeled and represented [14]. Vila Nova de Cerveira is a municipality in the district of Viana do Castelo in Portugal. In this scenario two hundred and twenty objects were modeled including public equipment, relationships and services [14]. They faced some challenges in the development process such as how the context aware application must interact with the Context Manager application [14]. One of the advantages of the researcher's general approach is the freedom to use the Context Manager in several ways, by modifying or creating new interaction models and by adding different selection algorithms for object querying [14]. The researcher faced another challenge in the deployment of the solution which was the provision of context information which is obtained the location context dimension of mobile phones by the cell identification from the mobile phone 56 operators [14]. The solution for the location information was to create a service that feeds the location to the model using as a source GPS embedded in the mobile device [14].

Jonna H. [11] had studied the user interaction issues related to context-aware mobile devices by conducting several case studies, which relate to location-awareness, information sharing and collaboration, privacy, and end-user programming with context aware mobile applications. These studies were used as the basis for developing design guidelines, which were then evaluated and iterated. The revised guidelines seek to offer some tangible help to designers, who are not necessarily specialized either in context awareness or interaction design [11]. The design guidelines include factors related to the uncertain character of context awareness [11]. The user maintains control over the device in any situation because an appropriate level of automation for executing actions needs to be selected, and user control secured [11]. In relation to the uncertainties in context recognition, user control and user's interruptability must be balanced and appropriate visibility to system status provided [11]. As context-awareness may generate or offer access to large amounts of data or services, it is important also to avoid information overflow [11]. Moreover, the application design should respond to the user's needs on personalization and privacy, and to take into account the restrictions of the social context of the use situation [11].

Oscar L. [25] provided some suggestions on interface design for mobile devices which were results from the design process of a prototype for mobile shopping. Additionally, the evaluation of a number of guidelines and methods for usability would show which could be used most efficiently [25]. The tests and evaluations of the prototype provided suggestions for the improvement of the prototype [25].

4. GUIDELINES FOR DESIGNING MOBILE APPS

According to Al-Harigy (2014), fifty nine guidelines were filtered from different user interface design resources and collected for designing applicable mobile apps that would address ten different contexts of use to insure good user experience while using the mobile apps, especially when the user is not in an ideal situation. These guidelines are as follows (while the details of the sources, justifications for using them, and the descriptions of each are explained in AlHarigy (2014)):

Guidelines (GL) 1: Analysis Guidelines

- GL 1.1: Know your users [24]; [25]; [26].

- GL 1.2: Determine the purpose of the site / service and identify the primary goals of the website before beginning the design process [27]; [28]; [29].
- GL 1.3: Decide whether you need more than 1 mobile site [30]; [28].
- GL 1.4: Quick access to the full site and back [31]; [28]; [32].
- GL 1.5: Ensure the site information is up-to-date [33]; [29].
- GL 1.6: Provide a functional bilingual website [33]; [34]; [35].

GL 2: Page Layout Guidelines

- GL 2.1: Design for portrait layout [36].
- GL 2.2: Divide the screen area into title, content, and navigation from top to bottom [36].
- GL 2.3: The main content of the screen and the most important information should be shown at the top [29]; [36]; [27]; [37].
- GL 2.4: Avoid using wide elements [28]; [36].
- GL 2.5: Minimize white spaces on the page [29]; [36].
- GL 2.6: Elements of mobile interfaces such as names, colour schemes, and dialog appearances should be the same as their desktop counterparts [28].
- GL 2.7: Place a logo or logos in a consistent place on every page to ensure users are fully aware they are on your website [27]; [33]; [28]; [35].

GL 3: Guidelines for Using Colors

- GL 3.1: Limit the number of different colors used on a page [36].
- GL 3.2: Use colors meaningfully [36].

GL 4: Simplicity and Clarity Guidelines

- GL 4.1: Avoid visual noise and clutter [29]; [36].

GL 5: Consistency Guidelines

- GL 5.1: Maintain consistency with the platform of use [29]; [36]; [35].
- GL 5.2: Apply consistent design and layout throughout the site [36]; [35].

GL 6: Content Selection Guidelines

- GL 6.1: Ensure that content is suitable for use in a mobile context [36].
- GL 6.2: Provide content that is engaging, relevant, and appropriate to the audience [29]
- GL 6.3: Only the most relevant and essential information should be shown [36]; [28].
- GL 6.4: Use clear and simple language [36]
- GL 6.5: Provide a short but descriptive page title [36]

GL 7: Visual and Interaction Design Guidelines

- GL 7.1: Select the font and background color that provide sufficient contrast and would not hamper the visibility of text or links [5]; [31]; [35]; [7].
- GL 7.2: Keep fonts large to optimize the reading process [31]; [36]; [29].
- GL 7.3: Organize text using sub-headings and links [36]
- GL 7.4: Minimize margins [36]
- GL 7.5: Avoid having too many text styles and sizes on the same page [36]
- GL 7.6: Organize documents so they are readable without requiring an associated style sheet [29]
- GL 7.7: Ensure that text highlighting techniques are not confusable with static contents and links [36]

GL 8: Guidelines for Using Images and Icons (Graphics)

- GL 8.1: Minimize the use of images [38]; [28]; [27]; [39]; [40]; [41].
- GL 8.2: Avoid using large or high resolution images [36]
- GL 8.3: Handheld mobile device's icon design should be as direct, simple and unique as possible [7]; [38].
- GL 8.4: Icon color design cannot use more than five kinds of colors [7]
- GL 8.5: For touch phones, leave generous amounts of space around widgets such as radio buttons, arrows for dropdown boxes, checkboxes, scrollbars, and links [28]; [42].

GL 9: Guidelines for Using Tables

- GL 9.1: Do not use tables unless the device is known to support them [36]
- GL 9.2: The table width and height should not exceed the display width and height [36]

GL 10: Site Navigation Design Guidelines

- GL 10.1: Provide consistent navigation mechanisms [36]
- GL 10.2: Keep the number of levels in a hierarchical structure few in number (Use a flat hierarchy) [36]; [43].
- GL 10.3: Use links to the main screen and do not repeat the navigation on every page [36]; [32]; [44].
- GL 10.4: Use the “back” command [36]; [37].
- GL 10.5: Balance the choice between scrolling and paging [36].
- GL 10.6: Limit scrolling to one direction [31]; [36]; [44]; [39].
- GL 10.7: Minimize the amount of scrolling [31]; [36]; [29]; [45].
- GL 10.8: Limit navigation options and keep them direct [31]

GL 11: Guidelines for Managing Hyperlinks

- GL 11.1: Use text for links rather than images where possible [5]; [27]; [40]; [29].
- GL 11.2: Clearly identify the target of each link [36].
- GL 11.3: Provide large target size and padding [31]; [36].

GL 12: User Input Guidelines

- GL 12.1: Reduce or completely eliminate the need for data input, especially text input [31]; [36]; [29].
- GL 12.2: Replace text input with a list selection [36]; [28]; [29]; [46]; [47].
- GL 12.3: Automatically place a blinking cursor at the beginning of the first data entry field when a data entry form is displayed on a page [29]

GL 13: Feedback Guidelines

- GL 13.1: Indicate visited and unvisited links [36]; [29].
- GL 13.2: Provide an informative error message [36]; [29].

GL 14: Mobile Context Guidelines

- GL 14.1: Ensure that the user interface elements are clearly visible in low light [42]; [34].
- GL 14.2: Take advantage of inbuilt functionality [30]; [28].
- GL 14.3: Take into account the impact of the social context [11]; [47]; [48].
- GL 14.4: Design for limited and split attention [47]
- GL 14.5: Allow for single or no-handed operation [47]
- GL 14.6: Make sure there is an option for large font [48]

Different contexts of use that occur while using mobile apps that may affect their usability, so the mobile user interface design guidelines must take into account and address each of them. According to Kumar and Sinha (2007), we have to consider four main contexts to adapt the content. Table 1 represents the main categories of context and their related contexts of use:

TABLE 1: Main categories of contexts and their related context of use.

Main contexts	Explanation	Context of use
Personal context	Any information that is used to describe the user's personal characteristics and information, such as name, gender, date of birth, and his service and content preferences. These contexts are user personal characteristics context, mobility context and critical time context	<ul style="list-style-type: none"> • User personal characteristics context: Contains the guidelines that relate to users' characteristics, such as age, gender, educational level, and familiarity for using the mobile device that the developer needs during the analysis phase. • Mobility context: Contains the guidelines relating to using information and organizing the mobile device interface content to be appropriate to use while users are moving and engaging in daily activity. • Critical time context: Contains guidelines that relate to the use of the mobile app to find information in urgent situations that affect the users' safety

Main contexts	Explanation	Context of use
Device context	Any information that is used to characterize the user's mobile device. It is critical to specify the user device capabilities in M-Government applications because they can have a big impact on what content is appropriate and meaningful to be delivered to the user, such as small screen context and mobile device characteristics context, content context, and interface elements consistency context.	<ul style="list-style-type: none"> • Small screen context: Contains the guidelines relating to the mobile device screen and its limitations, such as the design layout, margins, space between the elements, and images. • Mobile device characteristics context: Contains the guidelines relating to the mobile device characteristics and the interface design, such as using specific colors and fonts due to the device's capability. • Content context: Contains the guidelines relating to the content organization in the mobile app user interface. • Interface elements consistency context: Contains the guidelines that relate to maintaining the consistency between the interface elements through all website pages so the user feels that he/she is on the same website while navigating, such as by using the logo in a consistent place on all web pages.
Connectivity context	Specifying the type of wireless technology that the user will use because each of them has different data transfer rates such as network connectivity context.	<ul style="list-style-type: none"> • Network connectivity context: Contains the guidelines that relate to using specific features while taking into account the users' different connection types and ensuring the speed of loading the website pages.
Location context	Includes any information that describes the user location or any information related to location, such as lightning conditions context and social situations context.	<ul style="list-style-type: none"> • Lighting condition context: Contains the guidelines that relate to use specific features in designing the mobile app according to the different lighting levels while using the mobile app which affect the website usability. • Social situation context: Contains all of the guidelines that take into account the environment around the user while using the mobile device, such as the noise and the split attention.

Table 2 points to the guidelines from Al-Harigy (2014) that address the contexts of use presented in Table1. The proposed guidelines from Al-Harigy (2014) are distributed between the different contexts of use where each guideline address more than one context of use. The following relate the guidelines to the context of use issues (Table 2):

TABLE 2: The contexts of use with the related guidelines.

Context of use	Related guidelines
Users' personal characteristics context	GL#1.1; GL#1.2; GL#1.6; GL#6.2; GL#6.4; GL#7.2; GL#14.6.
Small screen context	GL#2.1; GL#2.2; GL#2.4; GL#2.5; GL#3.1; GL#4.1; GL#6.5; GL#7.1; GL#7.4; GL#7.5; GL#8.1; GL#8.3; GL#9.2; GL#10.3; GL#10.5; GL#10.6; GL#10.7; GL#10.8; GL#11.1; GL#12.1.
Mobile device characteristics Context (different screen size, supporting font type, different resolution of the mobile devices, memory size)	GL#3.2; GL#5.1; GL#7.1; GL#8.2; GL#8.3; GL#8.4; GL#9.1; GL#9.2; GL#10.4; GL#11.1.
Content context	GL#7.6; GL#10.2; GL#10.5; GL#10.7; GL#11.2; GL#13.1.
Lighting conditions context	GL#3.2; GL#7.1; GL#7.2; GL#8.4; GL#11.1; GL#14.1; GL#14.6.
Mobility context (context of use for the mobile device, such as using it while walking and moving, waiting in a queue, urgent situations, etc.)	GL#2.3; GL#3.2; GL#6.1; GL#6.2; GL#6.3; GL#6.5; GL#8.3; GL#8.5; GL#10.2; GL#10.3; GL#10.5; GL#10.8; GL#11.3; GL#12.1; GL#12.2; GL#12.3; GL#14.1; GL#14.4; GL#14.5.
Network connectivity context	GL#8.1; GL#8.2; GL#11.1.
Social situations context (such as noise level, limited attention)	GL#2.3; GL#3.2; GL#6.3; GL#10.2; GL#14.3; GL#14.4.
Interface elements consistency context	GL#2.6; GL#2.7; GL#5.1; GL#5.2; GL#8.1; GL#10.1.
Critical time context	GL#10.2; GL#12.1; GL#12.2; GL#12.3.

5. TESTING THE PROPOSED GUIDELINES

The contexts of use guidelines mentioned in Table 2 were given to an expert user with a computer Science background with no design experience to design a mobile version of the PME website. PME is a website example of a citizen-centered e-service website that is used in an emergency to provide information that users may need in critical situations. The PME desktop website was chosen for the following reasons:

- It does not have mobile version.
- It contains current updated information compared to other e-government websites.
- It has an early warning system and weather forecast features that can be used for emergency situations, such as dangerous sand storms or flooding.
- The PME website (Figure 1) contains services that could be used by the citizens on the go and in emergencies such as weather forecasts, early warnings, and emergency calls.

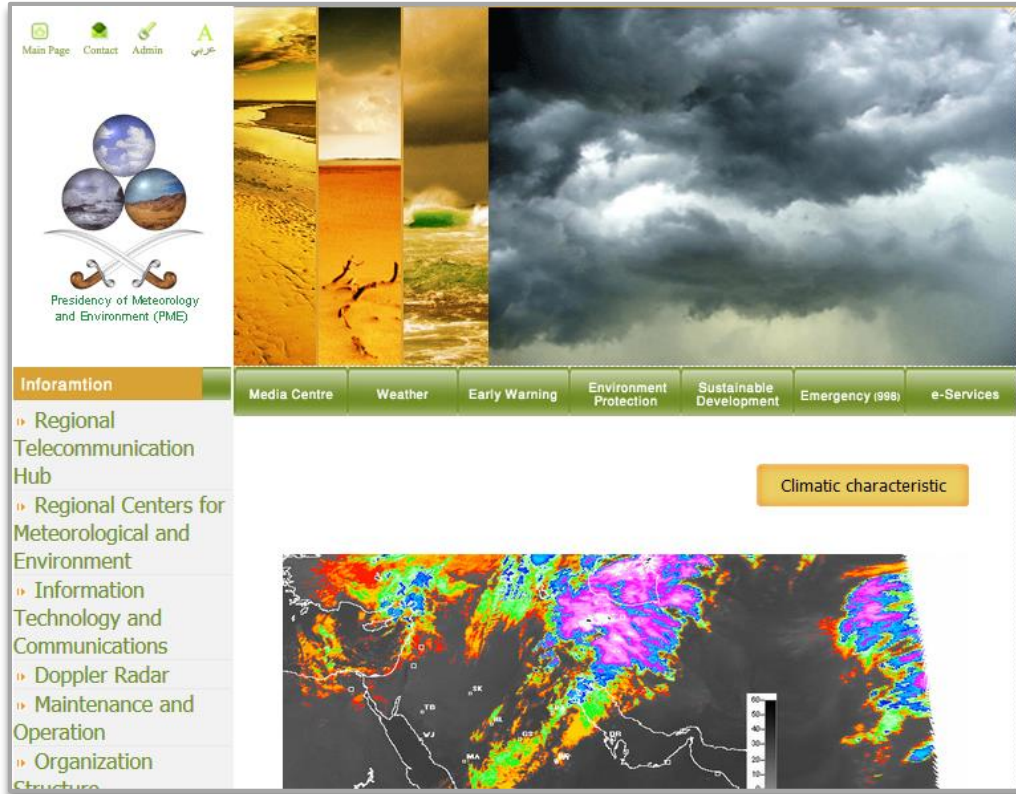


FIGURE 1: PME Desktop Website.

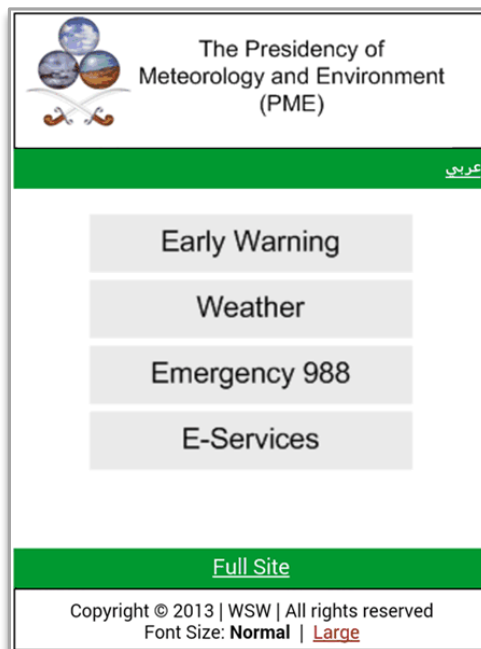


FIGURE 2: Proposed PME Mobile App.

The proposed PME mobile app (Figure 2) was designed by using Adobe Dreamweaver CS6 because it contains an HTML5 editor and it allows the developer to choose the size of the mobile interface.

According to Nielsen (2012) [18], there are five parameters for usability, as mentioned before, which covered in this research:

- Efficiency of use
- Subjective Satisfaction
- Learnability
- Memorability
- Low Errors Rate

The usability test of PME's mobile app was conducted with 15 participants who were local Jeddah citizens whose ages ranged from 20 to 40 years who had different educational backgrounds and mobile devices. An expert user with a background in computer science performed the tasks and the time measured in seconds was calculated for each task by using a stopwatch. This time was used as a base time or as a criteria for comparison. The usability test tasks were typical tasks that simulate information or broadcasts needed by users in urgent situations while they are on the move in real time. The tasks include finding all of the cities that have early warnings and their duration, as well as the description of the early warning situation in a city, emergency calls, notifications sent about incidents, locating the weather forecast for a city, and customization.

Two methods were used for evaluating the mobile app's usability: performance measures and subjective measures. Performance measures were calculated by giving a set of nine tasks to each of the 15 users to examine the mobile app calculating time on task for each user. To test the applicability of the proposed guidelines and to simulate the different contexts of use while using the mobile app, users were tested while moving in different environmental conditions (e.g., lighting, heat, indoor, outdoor, etc.). They were asked to use one hand while performing the tasks. All of the tasks were read to the users by the observer of the test because they were walking while performing the tasks.

Table 3 shows the base time and the users' time for each task. Figure 3 presents the comparison between the base time and the average time for all users.

TABLE 3: Times calculated for the expert and the users.

Users	Tasks								
	Task1	Task2	Task3	Task4	Task 5	Task 6	Task 7	Task 8	Task 9
Expert	4.3	8	1.3	1.5	6.8	10	1.3	1.9	3.86
User 1	4.11	8	3.5	1.5	9.98	12.61	3	4	4.92
User 2	4.05	5.45	3.43	1.52	8.36	17.26	1.5	2	2.88
User 3	7.18	8.47	1.61	6.06	13.63	22.14	5.63	1.65	1.95
User 4	10.8	10.55	4.45	5.29	12	18	5.56	5.9	5.5
User 5	5.18	3.71	4.14	7.35	5.19	23.28	1.51	5.13	2.44
User 6	6.65	4.52	1.66	6.72	7.54	16.77	12.18	9.16	18.37
User 7	4.16	4.24	2.39	5.42	7.05	16.85	4.47	6.46	7.56
User 8	4.75	6.18	1.31	8.14	5.8	20.54	1.69	4.83	4.63
User 9	3.24	3.28	1.64	2.5	3.89	14.62	3	1.64	3.5
User 10	3.54	4.28	2.1	4.6	4.19	10.65	2.45	2.3	3.23
User 11	7.52	6.33	1.48	8.45	8.05	23.47	6.16	11.86	2.17
User 12	8	8.36	2.69	5.59	8.45	29.48	7.39	3.81	5.32
User 13	4.14	5	1.83	6.92	6.07	19.17	2.16	7	4.2
User 14	5.34	7.5	1.69	5.4	6.5	11.31	3.23	3.12	4.7
User 15	5.3	5.2	2.1	3.4	5.1	11.54	2.34	7.22	3.2

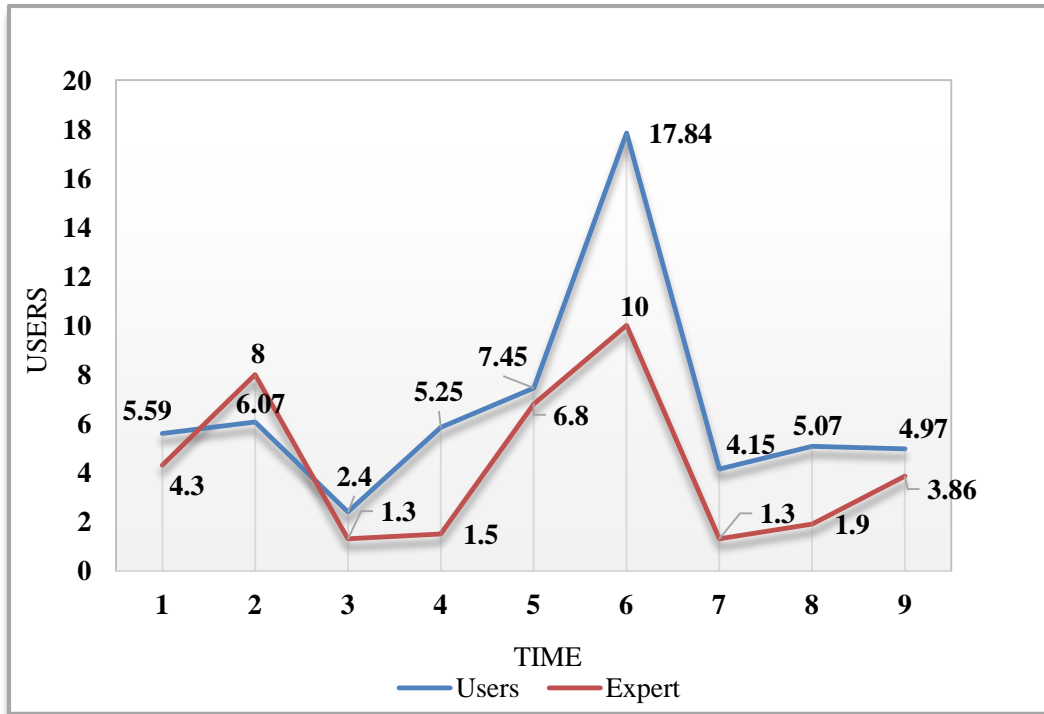


FIGURE 3: Comparison between the expert time and the users' average usage time.

Although some of the older users were not familiar with the use of mobile apps, the average time on task for all users were close to the time on task calculated for the expert. Some of the users even achieved less time on task than the expert time on task. The performance evaluation addressed four parameters of Nielsen's five usability parameters:

- Learnability: means the proposed mobile app is easy to learn for first time users and they could rapidly start working with it.
- Memorability: means that the proposed mobile app is easy to remember for the casual user.
- Efficiency: means that all the users could achieve the goal and complete the tasks accurately in amount of time close to or less than the expert's time.
- Low errors rate: means that the proposed mobile app has no error rate.

Subjective evaluations were conducted after users finished the tasks of the mobile app. The users evaluated the mobile app's user interface by giving each user a post-task questionnaire and a post-test interface evaluation questionnaire after completing all of the tasks. The post-task questionnaire was for rating each task on ease of use from a scale from 1 to 5, 1 being very easy. The post-test interface evaluation questionnaire was given to each user upon completion of all of the tasks. It contains 47 questions that are divided into five sections to rate the proposed mobile app in terms of text legibility, the effect on the content readability, clarity, ease of use, aesthetics, and overall satisfaction. All of the questions were close-ended. Each section has different rating scales according to the type of response appropriate for each item. According to the post-task questionnaire, eight tasks were rated by the users as being 100% very easy; in addition, one task was rated as being 73.3% very easy and another was designated as 26.7% easy. The subjective evaluation addressed the fifth parameter of Nielsen's five usability parameters which is satisfaction and positive attitude of the users towards the proposed mobile app. The results of the performance and subjective measurements show the satisfaction and positive attitude of the users toward the proposed PME mobile app. Thus, the proposed guidelines for designing a context-aware mobile app user interface were useful for producing a good user experience by using the PME mobile app.

6. CONCLUSION

The intensive use of mobile devices and the variable contexts of use that occur while using them deem it necessary to design a mobile app user interface that provides users with a good experience. A website designed for the desktop is not appropriate for use on a mobile device's small screen. Due to the lack of the research in mobile user interface design guidelines, it was necessary to collect user interface guidelines that are applicable to mobile user interface design and relate them to different contexts of use. The mobile user interface design guidelines that take into account the different contexts of use are especially important when users employ the mobile app of a website for their safety where errors and misunderstanding cannot be tolerated.

The guidelines collected from different literature resources and the different contexts of use that were addressed were used to design a mobile app version of the PME desktop website. The usability test was conducted on 15 users by using two methods of measurement. Each user performed nine tasks. Two questionnaires were given to the users. The usability test results show that the mobile app was designed by using the proposed guidelines while users were moving between various simulated environmental conditions in the approximate amount of time that it took an expert to complete the task; such considerations support the applicability of the proposed guidelines in designing the mobile apps. The results of the performance and subjective measurements show the satisfaction and positive attitude of the users toward the proposed mobile app of PME. Thus, the proposed guidelines for designing a context-aware mobile app user interface were useful for producing a good user experience while using the PME mobile app. For future work, we recommend to adapt the user interface according to the context of use. Although there have been several attempts to develop context-aware adaptation of mobile apps, it is not easy to develop systems that are adapted to single context of use, since none have a usable, well integrated and common solution fit for all users across many devices and platforms.

7. REFERENCES

- [1] K. B. Lee and R. Salman, "The Design and Development of Mobile Collaborative Learning Application Using Android," *Journal of Information Technology and Application in Education JITAE*, 2012.
- [2] S.-Y. Hung, C.-M. Chang and S.-R. Kuo, "User acceptance of mobile e-government services: An empirical study," *Government Information Quarterly* 30, Elsevier, pp. 33-44, 2013.
- [3] R. Harrison, D. Flood and D. Duce, "Usability of Mobile Applications: Literature Review and Rationale for a New Usability Model," *Journal of Interaction Science*, pp. 1-16, 2013.
- [4] H. S. Al-Khalifa, "Development of Mobile Government Websites: A Functional Design Approach," in *Proceedings on the 13th International Conference on Information Integration and Web-based Application and Services iiWAS'11*, New York, USA, 2011.
- [5] S. Shrestha, "Mobile Web Browsing: Usability Study," in *Mobility '07 Proceedings of the 4th international conference on mobile technology, applications, and systems and the 1st international symposium on Computer human interaction in mobile technology*, Singapore, 2007.
- [6] N. Z. b. Ayob, A. R. C. Hussin and H. M. Dahlan, "Three Layers Design Guideline for Mobile Application," in *International Conference on Information Management and Engineering ICIME '09*, Kuala Lumpur, 2009.
- [7] W. Qian and W. WenDao, "Interface Design of Handheld Mobile Devices for the Older Users," in *3rd International Conference on e-Education, e-Business, e-Management and e-Learning*, Singapore, 2012.

- [8] G. D. Abowd and A. K. Dey, "Towards a better understanding of context and context-awareness," in *In proceeding of the 2000 conference on Human Factors Computing Systems*, Netherland, 2000.
- [9] J. D. Davies, "Improving the Usability of Mobile Applications Through Context-Awareness," 2007.
- [10] R. A. Yaiz, F. Selgert and F. d. Hartog, "On the Definition and Relevance of Context-Awareness in Personal Networks," in *Third Annual International Conference on Mobile and Ubiquitous Systems: Networking & Services*, pp. 1-6. IEEE, California, USA, 2006.
- [11] J. Häkkinä, "Usability With Context-Aware Mobile Application, Case studies and design guidelines," Oulu, Finland, 2006.
- [12] P. D. Costa, L. F. Pires, M. v. Sinderen and J. G. P. Filho, "Towards a Services Platform for Mobile Context-Aware Applications," in *IWUC*, 2004.
- [13] L. Chittaro, "Distinctive Aspects of Mobile Interaction and their Implications for the Design of Multimodal Interfaces," *Journal on Multimodal User Interfaces*, vol. Volume 3, no. Issue 3, pp. 157-165, 2010.
- [14] A. Avila, "Application of a Context Model in Context-Aware Mobile Government Services," 2006.
- [15] M. Kumar and O. P. Sinha, "M-Government – Mobile Technology for e-Government," in *International conference on e-government*, India, 2007.
- [16] I. Zamzami and M. Mahmud, "Mobile Interface for m-Government Services: A Framework for Information Quality Evaluation," *International Journal of Scientific & Engineering Research*, vol. Volume 3, no. Issue 8, pp. 1-5, 2012.
- [17] J. Gong and P. Tarasewich, "Guidelines for Handheld Mobile Device Interface Design," in *Proceedings of DSI 2004 Annual Meeting*, 2004.
- [18] J. Nielsen, "Usability 101: Introduction to Usability," 2012.
- [19] T. Zefferer, "Mobile Government - E-Government for Mobile Societies, Stocking of Current Trends and Initiatives," Secure Information Technology Center, Austria, 2011.
- [20] MobiThinking, "Designing Usable Pocket Rockets: A Three Step Guide to Usability on the Mobile Web," 2013. [Online]. Available: http://mobithinking.com/sites/mobithinking.com/files/dotMobi_Mobile_Usability_Best_Practice.pdf. [Accessed November 2013].
- [21] A. Tsiaousis and G. Giaglis, "Evaluating the Effects of the Environmental Context-of-Use on Mobile Website Usability," in *7th International Conference on Mobile Business*, Barcelona, 2008.
- [22] F. G. UAE, "UAE Federal Government Web Guidelines," Ministry of Cabinet Affairs, Dubai, UAE, 2009.

- [23] J. Kolari, T. Laakko, T. Hiltunen, V. Ikonen, M. Kulju, R. Suihkonen, S. Toivonen and T. Virtanen, "Context-Aware Services for Mobile Users, Technology and User Experiences," 2004.
- [24] J. Kjeldskov and J. Paay, "Indexical Interaction Design for Context-Aware Mobile Computer Systems," in *Proceedings of the 18th Australia conference on Computer-Human Interaction: Design: Activities, Artefacts and Environments*, Sydney, Australia, 2006.
- [25] O. Lundahl, "Usability of Mobile Applications for Near Field Communication," 2009.
- [26] A. Clarke, "5 Mobile Website Usability Rules You Cannot Afford To Break," *usabilityygeek.com*, 2012.
- [27] A. Kaikkonen, "Usability Problems in Today's Mobile Internet Portals," in *2nd International Conference on Mobile Technology, Applications and Systems*, Guangzhou, 2005.
- [28] A. Grasso and T. Roselli, "Guidelines for Designing and Developing Contents for Mobile Learning," in *Proceedings of the IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE 2205)*, 123-127, 2005.
- [29] L. Kärkkäinen and J. Laarni, "Designing for Small Display Screens," in *Proceedings of the second Nordic conference on Human-computer interaction*, 31, 227-230, , Aarhus, Denmark, 2002.
- [30] R. Budiu and J. Nielsen, "Usability of Mobile Websites, 85 Design Guidelines for Improving Access to Web-Based Content and Services Through Mobile Devices," Nielsen Norman Group, 2011.
- [31] M. O. Leavitt and B. Shneiderman, "Research-Based Web Design & Usability Guidelines, Enlarged/Expanded edition," Washington: U.S. Government Printing Office, 2006.
- [32] A. Warsi, "7 usability guidelines for websites on mobile devices," 2007. [Online]. Available: <http://www.webcredible.co.uk/user-friendly-resources/web-usability/mobile-guidelines.shtml>. [Accessed 7 December 2013].
- [33] D. Seward, "Designing Usable Mobile Websites," Peak Usability, 2011.
- [34] J. Rabin and C. McCathieNevile, "Mobile Web Best Practices 1.0-Basic Guidelines, World Wide Web Consortium W3C, Recommendation REC-mobile-bp," July 2008. [Online]. Available: <http://www.w3.org/TR/2008/REC-mobile-bp-20080729/>. [Accessed 7 December 2013].
- [35] D. Dubai eGovernment, "Dubai Government Website Guidelines, Version 3," Dubai eGovernment Department, Dubai, 2011.
- [36] U. N. UN, "E-Government Survey 2012, E-Government for the People," United Nation, New York, 2012.
- [37] G. NSW, "NSW Government Web Guidelines," The NSW Department of Premier & Cabinet, New South Wales, Australia, 2013.
- [38] U. A. Zamzami, "Design of a Context-Aware User Interface in Mobile Learning," Unpublished Dissertation, 2010.

- [39] T. Fidgeon, "Mobile apps – some usability guidelines," 26 April 2012. [Online]. Available: <http://www.spotlessinteractive.com/articles/usability-research/mobile-app-guidelines.php>. [Accessed 7 December 2013].
- [40] J. Jung, "The Research of Mobile User Interface Design Components From the Standpoint of Universal Design for Learning," in *IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE'05)*, 2005.
- [41] M. Hassan, T. Jaber and Z. Hamdan, "Adaptive Mobile-Government Framework," in *International Conference on Administrative Development: Towards Excellence in Public Sector Performance*, Riyadh, 2009.
- [42] UTexas, "Mobile Web Site Guidelines," The University of Texas at Austin, 2013. [Online]. Available: <http://www.utexas.edu/brand-guidelines/web-guidelines/mobile>. [Accessed 7 December 2013].
- [43] N. Craig, "Mobile Website design & development guidelines," The Dot Product, 3 November 2010. [Online]. Available: <https://thedotproduct.org/mobile-website-deign-development-guidelines/>. [Accessed 7 December 2013].
- [44] MSDN, "Pocket PC User Interface Guidelines," 2009. [Online]. Available: <http://msdn.microsoft.com/en-us/library/ms854763.aspx>. [Accessed 7 December 2013].
- [45] S. Ma, "Designing for the Mobile Web: Special Considerations," UX matters, 17 January 2011. [Online]. Available: <http://www.uxmatters.com/mt/archives/2011/01/designing-for-the-mobile-web-special-considerations.php>. [Accessed 2013 December 2013].
- [46] D. Lobo, K. Kaskaloglu, C. Kim and S. Herbert, "Web Usability Guidelines For Smartphones: A Synergic Approach," *International Journal of Information and Electronics Engineering*, vol. Volume 1, no. Issue 1, pp. 33-37, 2011.
- [47] D. Roberts, "Usability and Mobile Devices," 1 May 2012. [Online]. Available: <http://www.usability.gov/get-involved/blog/2010/05/mobile-device-usability.html>. [Accessed 7 December 2013].
- [48] J. L. Lentz, "User interface design for the mobile web - Best practices for designing applications for multiple device platforms - IBM," IBM Corporation, 2011.
- [49] P. Tarasewich, J. Gong and F. Nah, "Interface Design for Handheld Mobile Devices," in *Proceedings of the Americas Conference on Information Systems AMCIS, USA*, 2007.
- [50] A. Kaikkonen, E. Kaasinen and P. Ketola, "Handheld Devices and Mobile Phones," in *The Universal Access Handbook*, CRC, 2009, p. Chapter 11.
- [51] H. Al-Nuaim, "Context-Aware Mobile Interface Design fo M-government," in *User-Centric Technology for Nonprofit and Civi Engagements*, Springer, 2014, pp. 171-186.
- [52] L. M. AlHarigy, "The Design of a Context Aware Mobile Government E-Services," Unpublished Dissertation, Jeddah, 2014.
- [53] L. Cerejo, "Guidelines and Best Practices, The Elements Of The Mobile User Experience," 2012. [Online]. Available: <http://mobile.smashingmagazine.com/2012/07/12/elements-mobile-user-experience/#more-111967>. [Accessed 7 December 2013].