Mapping Usability Heuristics and Design Principles for Touchscreen-based Mobile Devices

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ABSTRACT
Touchscreen-based mobile devices (TMDs) are one of the most popular and widespread kind of electronic device. Many manufacturers have published its own design principles as a guideline for developers. Each platform has specific constrains and recommendations for software development; specially in terms of user interface. Four sets of design principles from iOS, Windows Phone, Android and Tizen OS has been mapped against a set of usability heuristics for TMDs. The map shows that the TMDs usability heuristics cover almost every design pattern with the addition of two new dimensions: user experience and cognitive load. These new dimensions will be considered when updating the proposal of usability heuristics for TMDs.

Categories and Subject Descriptors
H.5.2 [Information Interfaces and Presentation]: User Interfaces – Ergonomics, Graphical user interfaces (GUI), Input devices and strategies, Interaction styles, Screen design, User- centered design.

General Terms
Human Factors, Verification.

Keywords
Usability heuristics, design principles, touchscreen-based mobile devices, mapping.

1. INTRODUCTION
Mobile devices are considered an extension of the user's body in terms of portability and amount of functionalities gathered in one single product. Everyday tasks can be achieved through the use of a mobile device, being touchscreen-based ones the most popular kind. Due to this, the development of touchscreen-based mobile applications is raising (and rushing) and do not always consider a user-centered approach.

Main operating systems are: iOS, Android, Windows Phone and (the overcoming) Tizen OS. Each platform has its own constrains when asking developers for designing new applications. The previously named operating system have published on its respective websites a set of design principles as a guideline for software development.

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As a previous step for the development of user-centered design patterns for touchscreen-based mobile devices (TMDs), a set of 12 usability heuristics was proposed [5] in order to analyze TMDs interfaces and detect common issues. In this paper we map the set of heuristics with the design principles in order to check if the proposal covers all the principles' dimensions and to see if there are some left-out dimensions that could be used as feedback for an update of the heuristics.

This paper is structured as follows: section 2 exposes the theoretical background of the research. Section 3 presents the mapping, along with the methodology and the sources. Finally section 4 presents the conclusions and future work.

2. THEORETICAL BACKGROUND
2.1 Mobile Devices
A mobile device is as a small electronic appliance, with some processing capabilities, with permanent or intermittent connection to a network. According to this definition, some examples of mobile devices are: smartphones, tablets, laptops or GPS devices, among others [4].

The adopted taxonomy for this research [12] classifies mobile devices into the following categories: (1) Mobile Standard PC, (2) Mobile Internet Devices, (3) Handhelds or PDA, (4) Smartphones, (5) Feature Phones, (6) Simple Phones and (7) Special Terminals.

According to the adopted taxonomy, TMDs are part of almost every class. Touchscreen-based mobile devices are every mobile device that has a touch-sensitive display (touch-screen).

2.2 Usability
Traditionally, the most common definition of usability is the one proposed by the ISO/IEC 9241: "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" [6].

On the other hand, many authors have their own definitions of usability. Shackel [13], defines usability as: "the capability in human functional terms for a system to be used easily and effectively by the specified range of users, given specified training and user support, to fulfill the specified range of tasks, within the specified range of scenarios".

ISO/IEC 9126-1 describes six categories of software quality that are relevant during product development including quality in use with usability defined more narrowly as ease of use [7]. ISO 20282 related to ease of operation is concerned with the usability of the user interface of everyday products [9].

The ISO/IEC 25000 series of standards was developed to replace and extend ISO/IEC 9126. The main goal of the ISO/IEC 25000 SQuaRE (Software Product Quality Requeriments and Evaluation) standard is to organize, enhance and unify concepts related to two main processes: software quality requirements specification and software quality evaluation, supported by the process of software quality measurement [8].

2.3 Design Principles

Design principles are prescriptive rules describing how visual techniques affect the perception and cognition of the information in a display [1]. In this practical case, design principles are design recommendations for developers for their applications to comprise platform constrains.

In general, design principles are wide, abstract and hard to transform into concrete design elements. They are descriptive and lack of metrics.

2.4 Usability Heuristics for TMDs

In our previous work, we presented two sets of usability heuristics for touchscreen-based mobile devices in three iterations. For the development of the proposal we used a methodology proposed by Rusu et al. which consists of 6 steps [11]. The third iteration was focused in the refinement of the second set and redefined the set of 12 specific usability heuristics for touchscreen-based mobile devices [5]. The set is presented in Table 1.

Table 1. Usability heuristics for TMDs

ID	Heuristic	Definition
TMD1	Visibility of system status	The device should keep the user informed about all the processes and state changes through feedback and in a reasonable time.
TMD2	Match between system and the real world	The device should speak the users' language instead of system-oriented concepts and technicalities. The device should follow the real world conventions and display the information in a logical and natural order.
TMD3	User control and freedom	The device should allow the user to undo and redo his actions, and provide clearly pointed "emergency exits" to leave unwanted states. These options should be preferably through a physical button or similar.
TMD4	Consistency and standards	The device should follow the established conventions, on condition that the user should be able to do things in a familiar, standard and consistent way.
TMD5	Error prevention	The device should hide or deactivate unavailable functionalities, warn users about critical actions and provide access to additional information.
TMD6	Minimize the user's memory load	The device should offer visible objects, actions and options in order to prevent users to memorize information from one part of the dialogue to another.
TMD7	Customization and shortcuts	The device should provide basic and advanced configuration options, allow definition and customization of (or to provide) shortcuts to frequent actions.
TMD8	Efficiency of use and performance	The device should be able to load and display the required information in a reasonable time and minimize the required steps to perform a task. Animations and transitions should be displayed smoothly.
TMD9	Aesthetic and minimalist design	The device should avoid displaying unwanted information in a defined context of use.
TMD10	Help users recognize, diagnose, and recover from errors	The device should display error messages in a language familiar to the user, indicating the issue in a precise way and suggesting a constructive solution.
TMD11	Help and documentation	The device should provide easy-to-find documentation and help, centered on the user's current task and indicating concrete steps to follow.
TMD12	Physical interaction and ergonomics	The device should provide physical buttons or similar for main functionalities, located in recognizable positions by the user, which should fit the natural posture of the user's hands.

3. THE MAPPING

3.1 Methodology

The mapping was performed by a member of the UseCV Research Group, from the Escuela de Ingeniería Informática, part of the Pontificia Universidad Católica de Valparaíso, Chile. The researcher counts with experience in both development of usability heuristics and mobile devices fields. Also he participated of the development process of the usability heuristics for touchscreen-based mobile devices [5]. He analyzed each design principle and associated it with one usability heuristic described in section 2.4.

After a first map was obtained, a group of 2 specialists from the same Research Group (UseCV) revised each association and made some corrections.

3.2 Sources

The design principles were extracted from the websites of the respective operating system developers. Main operating systems: iOS, Android, Windows Phone and (the overcoming) Tizen were selected. A total of 43 principles were revised: iOS(6), Android(17), Windows Phone(9) and Tizen(11) [2,3,10,14].

All the selected principles are written in a descriptive (not specific) way. They mainly consist of an ID (name in this case) and description.

3.3 The mapping

The map is presented below. Only few principles are presented for illustrative purposes. The map first describes the usability heuristic and the associated design principles. Finally, the new dimensions discovered through the mapping are presented. Each principle is identified by an acronym indicating the operating system and the given name. The acronyms (in parenthesis) are: iOS (iOS), Android (And), Windows Phone (WP) and Tizen (Tiz).

3.3.1 TMD4 - Consistency and standards

The associated principles are:

(iOS) Consistency: Consistency lets people transfer their knowledge and skills from one part of an app's UI to another and from one app to another app.

(And) If it looks the same, it should act the same: Help people discern functional differences by making them visually distinct rather than subtle. Avoid modes, which are places that look similar but act differently on the same input.

(And) Give me tricks that work everywhere: People feel great when they figure things out for themselves. Make your app easier to learn by leveraging visual patterns and muscle memory from other Android apps. For example, the swipe gesture may be a good navigational shortcut.

(WP) Get on the grid: The grid is the glue that gives your content the cohesion it needs.

3.3.2 TMD5 - Error prevention

The associated principles are:

(And) Never lose my stuff: Save what people took time to create and let them access it from anywhere. Remember settings, personal touches, and creations across phones, tablets, and computers. It makes upgrading the easiest thing in the world.

(Tiz) Make it clear what can be done: Disable or hide functions that are not available in certain circumstances. For example, you can disable the Save button to let users know a required field is empty.

3.3.3 TMD7 - Customization and shortcuts

The associated principles are:

(And) Let me make it mine: People love to add personal touches because it helps them feel at home and in control. Provide sensible, beautiful defaults, but also consider fun, optional customizations that don't hinder primary tasks.

(And) Do the heavy lifting for me: Make novices feel like experts by enabling them to do things they never thought they could. For example, shortcuts that combine multiple photo effects can make amateur photographs look amazing in only a few steps.

(Tiz) Understand individual user patterns: By taking the behavioral patterns of each user into account, your application can deliver a more personalized experience. For example, by ensuring the most frequently or recently used applications are easily accessible, you support users that want to find an application or content as quickly as possible.

(Tiz) Use customization to enhance usability: Make sure you support customization that not only improves your application's aesthetics but also enhances its usability. By providing accessibility functions, such as font sizes and a screen reader, you can help differently abled users navigate Tizen applications more conveniently.

3.3.4 TMD9 - Aesthetic and minimalist design

The associated principles are:

(And) Keep it brief: Use short phrases with simple words. People are likely to skip sentences if they're long.

(And) Only show what I need when I need it: People get overwhelmed when they see too much at once. Break tasks and information into small, digestible chunks. Hide options that aren't essential at the moment, and teach people as they go.

(WP) Who are you?: Find the typography that best reflects your app's personality.

(WP) Content over chrome: By removing the chrome and taking advantage of font, scale, and color, sender names and titles are easier to read.

(Tiz) Only display essential information as default: Differentiate between the essential information that's always displayed and any additional information that's only displayed when a user requests it.

3.3.5 TMD12 - Physical interaction and ergonomics

The associated principles are:

(iOS) Direct Manipulation: When people directly manipulate onscreen objects instead of using separate controls to manipulate them, they're more engaged with their task and it's easier for them to understand the results of their actions.

(And) Real objects are more fun than buttons and menus: Allow people to directly touch and manipulate objects in your app. It reduces the cognitive effort needed to perform a task while making it more emotionally satisfying

(And) Make important things fast: Not all actions are equal. Decide what's most important in your app and make it easy to find and fast to use, like the shutter button in a camera, or the pause button in a music player.

(WP) Let your content breathe: Relevant commands and functionality are apparent and easy to interact with.

(Tiz) Facilitate access to primary functionality: Display the functions users access most on the first screen. Use the Menu key to house any functions users might need less frequently.

3.3.6 Non-associated principles

Some of the design principles could not be associated with the usability heuristics. After discussion with specialists, the non-associated principles were labeled as new dimensions to be considered in future iterations of the usability heuristics.

3.3.6.1 User experience

(iOS) Aesthetic Integrity: Aesthetic integrity doesn't measure the beauty of an app's artwork or characterize its style; rather, it represents how well an app's appearance and behavior integrates with its function to send a coherent message.

(And) Delight me in surprising ways: A beautiful surface, a carefully-placed animation, or a well-timed sound effect is a joy to experience. Subtle effects contribute to a feeling of effortlessness and a sense that a powerful force is at hand.

(WP) Be alive: Live Tiles are responsive, alive, and engaging. Plus they can run the gamut of your imagination — from notifying you about new email to giving you the inside tip on drink specials at your favorite bar.

(Tiz) Put the emphasis on fun!: Users should find the process of accessing content an enjoyable one. By designing applications with visually compelling layouts and engaging, interactive graphics, you can enhance the user experience.

3.3.6.2 Cognitive load

(And) Only interrupt me if it's important: Like a good personal assistant, shield people from unimportant minutiae. People want to stay focused, and unless it's critical and time-sensitive, an interruption can be taxing and frustrating.

(Tiz) Present information according to importance: Offer information based on its degree of importance. For example, deliver simple messages, such as "Deleted" or "Shared", on the indicator to avoid interrupting the user in the main body of the application.

4. CONCLUSIONS

After analyzing 43 design principles proposed by four important mobile operating system developers, a map with usability heuristics for touchscreen-based mobile devices was made. A usability specialist analyzed each principle and associated it to a single usability heuristic for touchscreen-based mobile devices. Then a group of two specialists revised each association and made corrections.

Every single heuristic was associated with one or more principles checking the completeness of the usability heuristics set. Six of the 43 principles could not be associated with any heuristic. After discussion with specialists, the non-associated design principles were classified into two new dimensions called "User experience" and "Cognitive load". These dimensions will be considered when refining the proposal in a future iteration.

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